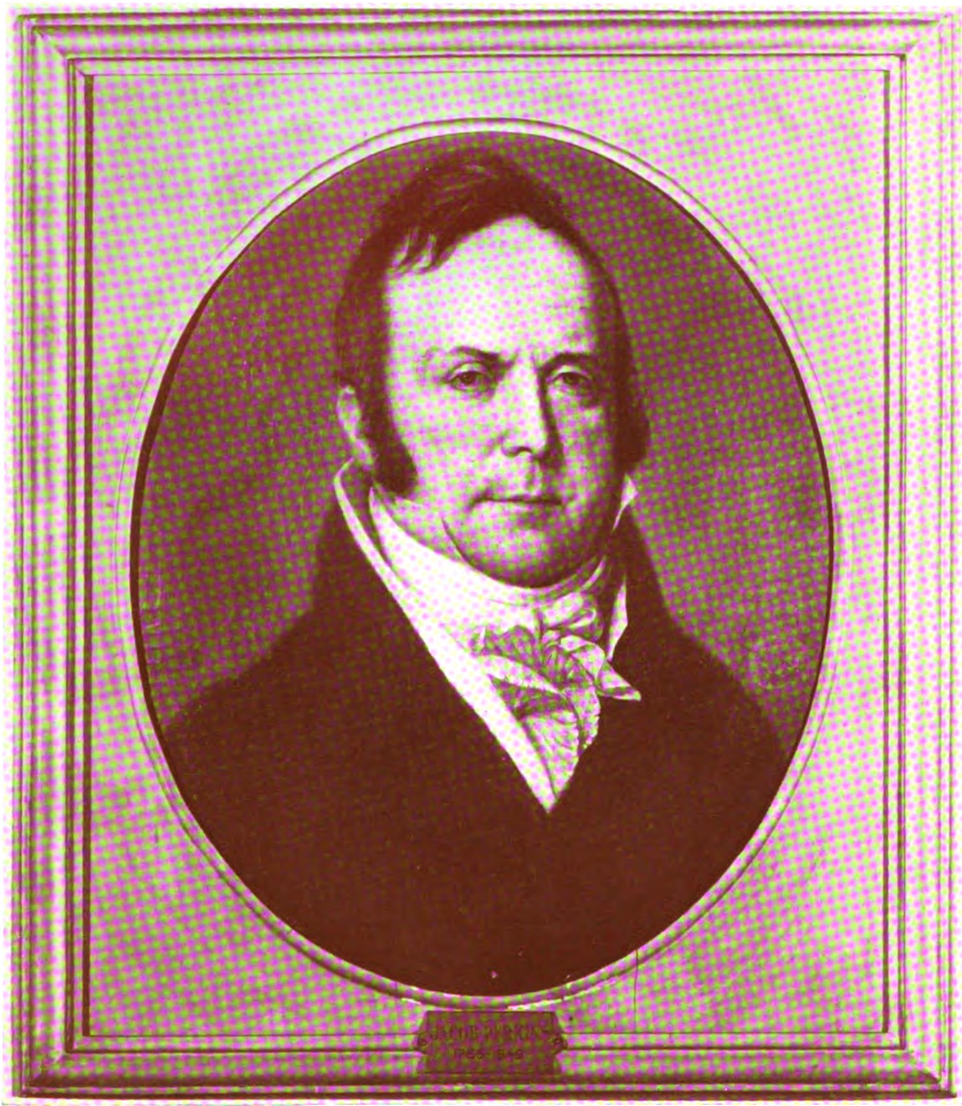


JACOB PERKINS
Aged 52 years
From a painting in the possession of The Franklin Institute, Philadelphia.

JACOB PERKINS

His Inventions, His Times, & His Contemporaries

BY

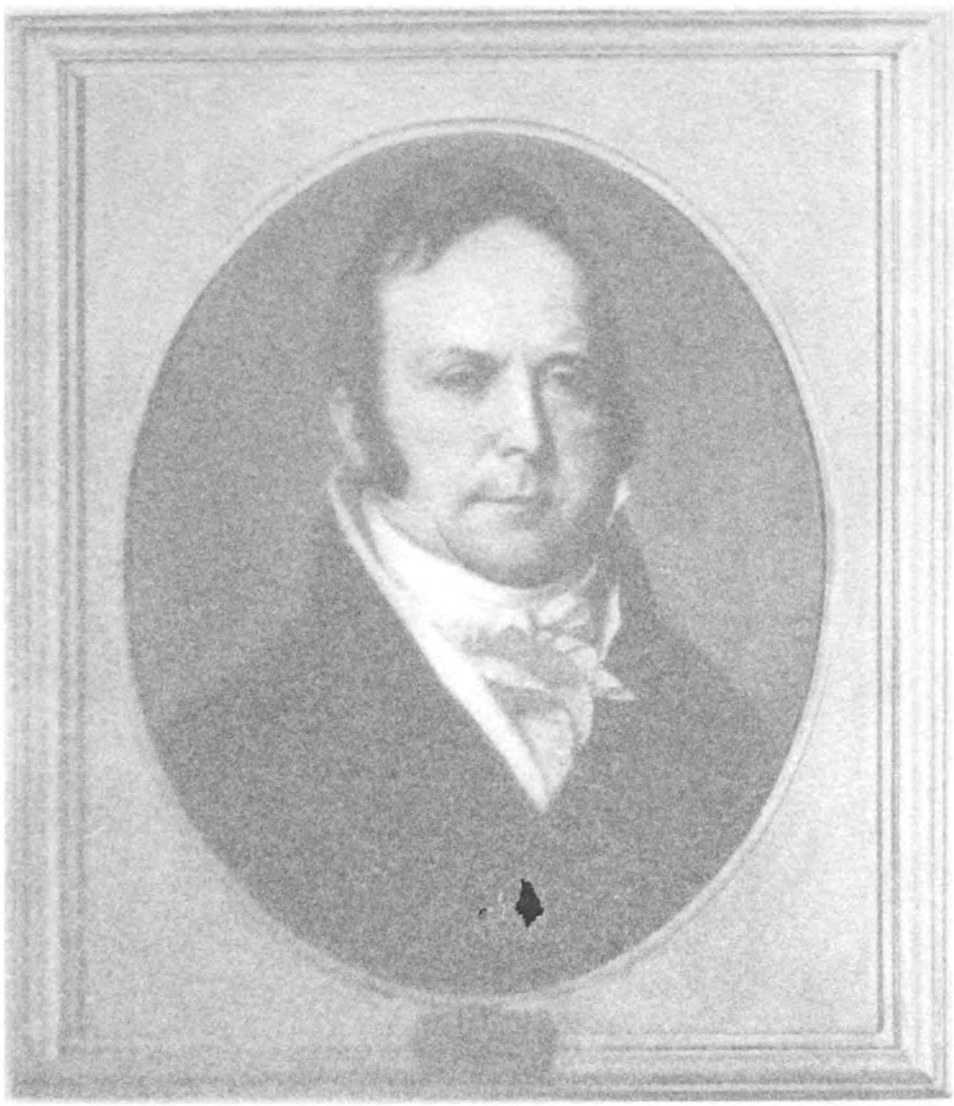
GREVILLE BATHE and DOROTHY BATHE

Authors of

Oliver Evans, a Chronicle of Early American Engineering,
an Engineer's Miscellany, etc.

PUBLISHED BY
THE HISTORICAL SOCIETY OF PENNSYLVANIA
PHILADELPHIA

1943



JACOB PERKINS

His Inventions, His Times, & His Contemporaries

BY

GREVILLE BATHE and DOROTHY BATHE

Authors of

Oliver Evans, a Chronicle of Early American Engineering, an Engineer's Miscellany, etc.

PUBLISHED BY
THE HISTORICAL SOCIETY OF PENNSYLVANIA
PHILADELPHIA

1943

Of this edition two hundred copies have been printed
of which this is number

169

PRESS OF
ALLEN, LANE AND SCOTT
PHILADELPHIA

DEDICATED

To the memory of the late

LOFTUS PATTON PERKINS

of London

PREFACE

THE authors believe that this volume limited as it is to 200 numbered copies will justify its publication, not entirely as a biography of Jacob Perkins, the inventor, but as a historical introspection of men, science and machines, which is the foundation of our modern technology.

The original hope of achieving a connected story of Perkins' life has not, however, been entirely fulfilled, for even with the assistance and wholehearted co-operation of many of Perkins' more direct descendants as well as other family connections, there has still been found wanting much that would have enhanced the continuity of the domestic and personal side of Perkins' life. His professional work has been more easily traced through contemporary writers, current newspaper accounts, and various documents and letters written by Perkins to acquaintances, close friends and business associates.

The actual gathering of the essential facts for this work has occupied the authors for about three years and covering as they do research in both hemispheres, the work has been prosecuted under considerable difficulties, with many delays and frustrations. Indeed, toward the final correlation, it appeared as though the section dealing with Jacob Perkins' long residence in England would present such gaps as to make the account seem unbalanced in comparison with the narrative of his activities in America. This situation was, however, notably relieved by the generous action of Dr. Henry Winthrop Dickinson of London, engineer and historian, who released to the authors a number of his personally collected notes on Jacob Perkins covering the English period of his life. And further by his timely introduction to Mr. Loftus Patton Perkins, a great grandson of the inventor, a resident of London, who did all in his power to further the completion of this volume by transcribing for the authors' use, a quantity of documentary material in his possession, which is now included in these pages. It is deeply to be regretted that Mr. Perkins passed away in 1940. During the aerial attacks on London in the fall of that year, during which several buildings were demolished by bombs in his immediate neighborhood, he suffered a heart attack which proved fatal on September 5th. We wish to express our sincere appreciation for the individual help given by so many of the residents of Newburyport and Amesbury and the research facilities offered us by the Historical Society of Old Newbury and the Public Library of Newburyport.

The bulk of the Perkins material available is widely scattered, only one collection of any magnitude can be remarked which is that of Mr. Charles H. Taylor of the *Boston Globe*. This collection is intrinsically and historically most valuable, containing as it does specimens of bank notes, postage stamps, coins and dies. The items deal principally with the engraving and stereographic side of Perkins' work and are now in the keeping of the American Antiquarian Society in Worcester, where the authors were afforded every facility for inspecting and reproducing documents necessary for this work.

There are two authentic portraits of Jacob Perkins, both oil paintings. One of these hangs in the Executive Office of the Franklin Institute in Philadelphia and is believed to be

the work of Charles Wilson Peale about the year 1818. The other portrait is by Chester Harding and was painted in 1824 during the artist's sojourn in London. This picture is in the possession of Messrs. Baker, Perkins Limited, engineers, of Peterborough, England, and hangs in the firm's Board Room beside a companion portrait of Perkins' wife and their granddaughter, Maria Louisa Bacon, who was then about seven years of age.

In addition, there is a very fine lithograph of Perkins, showing him in a standing pose, which was redrawn from the Harding portrait by Richard J. Lane for J. Miller of the American Library, London, and dated November, 1825. The only known copy of this in America is owned by Miss Margaret W. Cushing of Newburyport, who is a direct descendant of Jacob Perkins' half sister Mary who married Nicholas Johnson, whose daughter Elizabeth married John N. Cushing.

There is also in existence a life-size bust, artist unknown, of the great inventor, showing him at an advanced age, which is now in the possession of Messrs. W. W. Sprague and Company, successors of the original firm of Perkins, Bacon and Company, of Fleet Street, London.

Our deepest appreciation is also extended to Mrs. Mary Brown Thurlow, of Birmingham, Alabama, who furnished the authors with valuable information concerning the early antecedents of the Perkins family and to her cousins, Mr. and Mrs. Edward F. Brown of Newburyport. Mrs. Brown loaned the authors the silhouette of Angier March Perkins, which is reproduced in these pages, and Mr. Brown made the drawings of the Perkins Patent nail which are also included here. Mrs. Thurlow and Mr. Brown are directly descended from Abraham Perkins and Elizabeth Knapp Perkins, whose daughter Mary Jane married Moses Brown.

We are also indebted to Miss Adelaide W. Currier of Newburyport for her courtesy in showing the authors the Perkins plates and die in her possession. Miss Currier is descended from Lieutenant Aaron Pardee, an officer in the Revolutionary War, who married Jacob Perkins' sister Jane.

The authors freely acknowledge the assistance obtained from the many historical and biographical books of reference which have been read and due credit to their various authors is given in the text and footnotes of this volume. Appreciative thanks are also extended to the following Institutions, for permission to reproduce letters, illustrations and other items so necessary to round out this work.

The American Academy of Arts and Sciences, Boston, for copy of an original Perkins letter.

The American Antiquarian Society, Worcester, Massachusetts, for copies of holographs and prints.

The American Philosophical Society, Philadelphia, for copies of holographs and prints.

The Amesbury Public Library, Amesbury, Massachusetts, for assistance in research work.

The Bucks County Historical Society, Doylestown, Pennsylvania, for photographs of the Perkins fire engine in their possession.

Messrs. Baker, Perkins Limited, of Peterborough, England, for photographs of portraits and medals in their possession.

THE BRITISH MUSEUM, London, for copy of a specimen Perkins bank note.

THE CHASE NATIONAL BANK, New York, for their courtesy in allowing coins in their famous collection to be photographed for this work.

MESSRS. CORNISH BROTHERS LIMITED, Birmingham, England, for information supplied on early nail making.

THE ESSEX INSTITUTE, Salem, Massachusetts, for copies of holographs.

THE FRANKLIN INSTITUTE, Philadelphia, for permission to reproduce the Perkins portrait in their possession.

THE HISTORICAL SOCIETY OF PENNSYLVANIA, for copies of holographs.

THE LIBRARY COMPANY OF PHILADELPHIA, for copies from holographs, newspapers and prints.

THE MANCHESTER GUARDIAN, of Manchester, England, for general information.

THE MARINERS' MUSEUM LIBRARY, Newport News, Virginia, for a naval print of *U.S.S. Independence*.

THE MASSACHUSETTS HISTORICAL SOCIETY, Boston, for copies of holograph letters.

THE NAVAL RECORDS AND LIBRARY, Washington, for print of *U.S.S. Washington*.

THE NEW YORK PUBLIC LIBRARY, for copies of holographs.

THE PUBLIC LIBRARY OF THE CITY OF BOSTON, for holographs and other material.

The authors also wish to thank the following individuals for their help and co-operation, for which we are greatly indebted:

MISS MARY ALLBUTT, to whom we are indebted for the London research work, carried out under the most difficult conditions.

MRS. M. F. BALL, assistant librarian of the American Academy of Arts and Sciences, Boston, for transcriptions from the Minutes of the Society.

MISS CHARLOTTE C. BAYLEY, custodian of the Historical Society of Old Newbury, for her assistance to the authors during their Newburyport research.

MR. BARNEY CHESNICK, of the Philadelphia Library Company, for his excellent photographic work of maps and other historic documents.

MR. IRVING S. COLE, librarian of the Newburyport Public Library, for assistance in research work.

MR. FREDERIC W. COOK, Secretary of the Commonwealth of Massachusetts, for copies of holographs from the State Archives.

MRS. C. W. EVANS, librarian of the Mariners' Museum, Newport News, Virginia, for historical naval references.

MR. P. J. FEDERICO, editor of the *Patent Office Society Journal*, Washington, for his valued assistance and advice on patent matters.

MR. A. A. GOMME, librarian of the Patent Office Library, London, for his assistance in obtaining Perkins patent material.

MR. F. ABBOT GOODHUE, of New York, for his courtesy in permitting the reproduction of a copy of an original Perkins plate in his possession.

Miss Viola C. Hamilton, of the American Antiquarian Society, for her transcriptions of Perkins material.

Mr. W. Tregoning Hooper, of Falmouth, England, for his help on Cornish engineering history.

Captain Dudley W. Knox, U.S.N., Officer in charge of Naval Records, for his help in matters of early naval history.

Mrs. Ralph Ladd, librarian of the Ipswich Historical Society, for her assistance with the geneology of the Perkins family.

Mr. K. W. Luckhurst, secretary to the Royal Society of Arts, London, for his unvarying courtesy in replying so thoroughly to the authors' numerous inquiries.

Miss Gladys Müller, for her excellent photographic copy of the Perkins portrait in the Franklin Institute.

Mr. Walter A. R. Pertuch, librarian of the Franklin Institute, for his valuable assistance at all times.

Mr. John Spargo, of Bennington, Vermont, president of the Vermont Historical Society, for the information regarding Isaac Doolittle, and permission to quote from the publications of the Society.

Miss Harriet S. Tapley, librarian of the Essex Institute, Salem, Massachusetts, for her help with the Perkins Papers in the Institute library.

Mr. Seymour Thompson, librarian of the University of Pennsylvania Library, for his courtesy in permitting access to the stacks at all times.

Mr. Cushing Toppan, of London, for information regarding the Toppan family.

Mr. Robert W. G. Vail, librarian of the American Antiquarian Society, Worcester, for his courtesy and co-operation during the authors' research work in Worcester.

Mr. M. Richard Williams, of Philadelphia, for his efficient search of the early Philadelphia newspapers and periodicals.

Mr. Farran Zerbe, of New York, for his valued advice on numismatic matters.

The authors also acknowledge their indebtedness to all those persons both here and abroad who have aided so materially in the completion of this volume.

Philadelphia,
September, 1943.

G. B.
D. B.

LIST OF PLATES

LIST OF MAPS

ILLUSTRATIONS IN THE TEXT

APPENDIXES

INTRODUCTION

In presenting this volume on the life and work of Jacob Perkins, the authors have endeavored to outline as far as possible an accurate history of Perkins' many outstanding achievements and also not omitting his obvious failures. To students in general the name of Jacob Perkins, the American inventor, is fairly familiar but in this age it awakens little more response than the remembrance that he was the first to introduce steel engraving for the prevention of bank note forgery or that later he built engines which used prodigious steam pressures or that he invented a wonderful steam gun which poured forth a devastating stream of bullets. Posthumous fame so often rests on such sensational episodes alone as these that it is not difficult to realize why superficial biographical references are so often inadequate and misleading. Perkins was a man whose life was one of stupendous activity replete with a great variety of inventive effort, much of which has definitely left its influence on present day practice. Though the majority of Perkins' works were confined to the more useful and practical branches of mechanics, his brief excursions into the realm of natural philosophy as understood in his day, clearly indicate that he could have become an experimental scientist of great ability. But fundamentally Perkins lacked the persistence of purpose to pursue any one thing to a logical conclusion. Not that he lacked concentrative ability, for much of his work shows this in a marked degree but at times so much of his efforts were wasted upon intriguing enterprises which temporarily afforded him the exciting stimulus of some hoped-for momentous discovery. Perkins by nature was affable, kindly and tolerant and he was able to readily gain the support and loyalty of his friends and business associates whose imagination he was so well able to fire by his own enthusiasms. His ingratiating personalty and convincing manner enabled him to establish many favorable business contacts during his career and Perkins' partnerships, both legally sealed or tacitly understood, were many. These often lasted only a year or so and upon their dissolution seldom involved any unpleasant feeling nor the breaking of personal ties. No contemporary writer has handed down a dispassionate and unbiased appraisement of Perkins' character and temperament. The several portraits of him extant indicate his intellectual and introspective mind. One, an oil painting in the possession of the Franklin Institute, shows him at about fifty years of age with dark blue eyes and hair of a reddish brown color and a face strong but not aggressive. In build Perkins was rather short of stature but of compact and athletic frame. He was descended from a hardy line of New England settlers, famous for their vitality and tenacity. These inherited family characteristics no doubt contributed greatly to Perkins' ceaseless energy and enterprise which so often urged him to lay hold of a problem which interested him, more often than not without regard to its profitable outcome. To Perkins the pecuniary aspects did not play an all important part but the glory did, a fact which was apt to build up an immense anticipation which the outcome did not always justify. Perkins was not a good man of business in the accepted sense of money making, for more than once he had a fortune in his grasp only to have it elude him at the crucial moment through lack of attention to details or through misplaced confidence in others. The harrow-

ing failures of his latter years, followed by a premature retirement from active business, did much to dim his earlier fame. By the time of his death at the advanced age of 83 he had long outlived his usefulness, most of his friends and all of his ambitions. This with the passing of time has made Jacob Perkins a rather legendary figure. Posterity has by now almost forgotten his genius as an inventor of useful things, as well as his many constructive contributions to both science and industry.

Like to the falling of a star,
Or as the flights of eagles are,
Or like the fresh spring' gaudy hue,
Or silver drops of morning dew;
Or like a wind that chafes the flood,
Or bubbles which on water stood:
Even such is man, whose borrowed light
Is straight called in, and paid to-night.

The wind blows out, the bubble dies,
The spring entomb'd in autumn lies,
The dew dries up, the star is shot,
The flight is past,—and man forgot.

Henry King, 1592-1669

NEWBURYPORT

1766-1815

JACOB PERKINS

Jacob Perkins was born on July 9, 1766, in the small but thriving Massachusetts town of Newburyport. At this period, Newburyport was already a growing shipbuilding center and port of commerce situated on the northernmost part of the Massachusetts Bay colony, at the mouth of the winding Merrimac River. It ranked in importance during pre-Revolutionary days with Salem and Plymouth as a port of call for the coasting vessels and deep sea ships which represented the only tangible contact with the southern colonial settlements and the world at large.

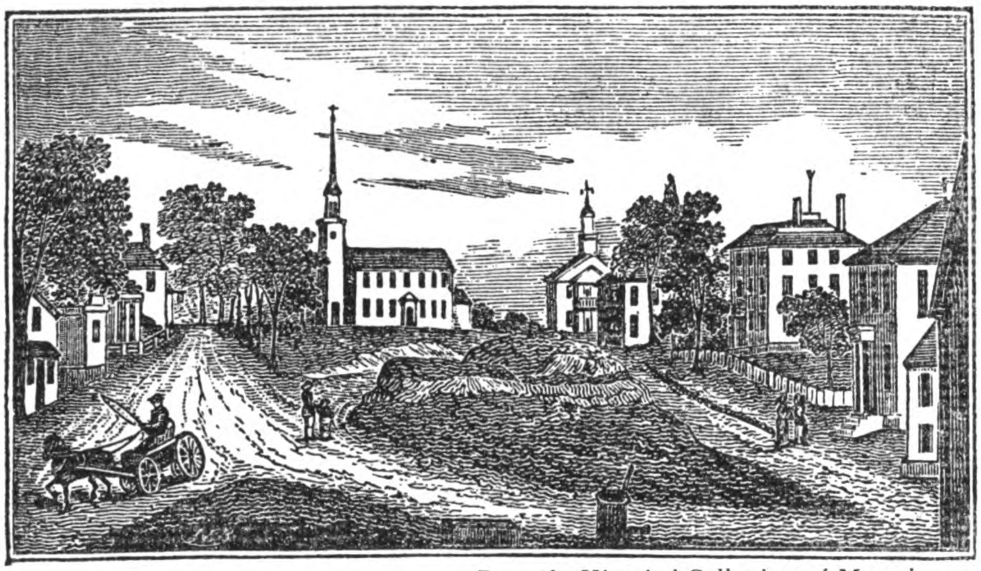
Newburyport in the earliest times formed the port of the old town of Newbury. The original settlers, who had landed here at the Indian place of *Quafcacanquen* in 1633, soon went on to reside at Ipswich. Two years later some of the leading citizens of Ipswich petitioned the General Court for permission to form a separate town to be called Newbury.

A Pikeman of 1630. Military Costume of John Perkins.

After some delay, the town was finally laid out in 1645. Four lanes were later extended from the highway, now called High Street, down to the Merrimac River and this small settlement of fishermen and their families along the strand became known as Newburyport. It was not until 1851 that the southern limits of Newburyport were sufficiently extended to include the northern part of the old town of Newbury.

In 1655 the first wharf was built by Captain Paul White at the foot of one of the four lanes, now called State Street. It was more than one hundred years, however, before the first shipyard was built by Ralph Cross and a few years later Jonathan Greenleaf was building small coasting vessels at the foot of Chandler Lane, now Federal Street. The deep sea trade then rapidly increased and the port was incorporated as a separate town in 1764. From then

on, until the outbreak of the Revolutionary War, commerce with the French West Indies was constant and profitable but the restrictions of the blockade during the Revolutionary War completely halted the shipbuilding industry in Newburyport and the town in consequence declined. Not until after the peace did the port regain its prosperity and this prosperity lasted until the disastrous fire of 1811. This fire destroyed most of the town's business center and the War of 1812 laid a further heavy hand upon the community's foreign trade. Newburyport revived again as a shipbuilding center about 1825, reaching its most impressive period in the 1840's when Donald McKay, the famous designer of early clipper ships, went to live there and formed a working partnership with William Currier. There on the Merrimac were built the *Mary Broughton*, the *Ashburton* and the *Courier*, acclaimed the world over for their speed and beauty of lines. Later still, the tall masts of deep



From the Historical Collections of Massachusetts

An early view of Ipswich, Massachusetts—showing the
First Congregational Church, founded in 1634.

sea vessels gave way to a more industrial trend. Factories lined the docks instead of ships. They manufactured such diversified products as silverware and shoes, textiles and iron work. Though Newburyport has never expanded much in its later years, as have the southern ports of Massachusetts, yet it has maintained a quiet progress of peaceful prosperity and to this day its old world charm is unharried and unbroken, as the spirit of its colonial days lives on.[1]

The founder of the American branch of the Perkins family was John Perkins, a west of England man of good yeoman stock. It is recorded that he was a pikeman of the 64th Regiment serving in the forces of King Charles I.

John Perkins, born in 1590, came from Gloucestershire and is said to have been a

[1] The authors are indebted to John James Currier's *History of Newburyport*, 1764-1909 (2 vols.), for much of the historical and biographical information concerning Newburyport which is used in the first part of this work.

native of Newent, an ancient Market Town in the Hundred of Botloe, situated in the forest of Dean. He was a self-determining man and espoused and clung to the simpler creeds of the Old Testament, which were the foundation of Puritanism. No doubt Perkins' loyalty to the Crown was somewhat tempered by the harsh dogmatic attitude of the English church at this time, then under the sway of William Laud, recently translated to the Bishopric of London, who, with the King, was ranged in antagonism against both parliament and Puritanism.

In 1628 with the founding of the Massachusetts Bay Colony, John Perkins' thoughts must have turned more and more toward that new land of religious and political freedom, so that in the year 1630, his decision made, he gathered together his worldly goods, his wife and family and journeyed to Bristol and on December 1, 1630, he embarked on the ship *Lyon* bound for Boston. There he arrived on February 5, 1631.

John Perkins remained in Boston until 1633 when he removed northwards with others to a place called by the Indians *Agawam*. This location was incorporated in 1634 as the town of Ipswich, £20 being paid to the Indian sagamore of Agawam for the town site in 1638.[2]

John Perkins resided here until his death in 1645. He had had six children, one of whom was named Jacob who was born in England in 1624. This Jacob Perkins continued to live in Ipswich and he in turn also had six children, among whom was a son Matthew born in 1665. This Matthew married Esther Burnham in 1685. From their numerous family came Matthew the second of that name who continued on the Perkins line until 1737 when he died, leaving a son Matthew the third who had been born in 1763 of his father's second marriage. Matthew the third moved to Newbury about 1748, at the time of his first marriage to Ann Greenleaf and to them were born twelve children, four sons and eight daughters between the years 1749 and 1762. In 1762 Ann died and the next year Matthew Perkins married Jane Dole, the widow of John Dole of Newbury. Of this second marriage

[2] This early settlement at Ipswich was part of the third great migration from England and by the year 1634, nearly four thousand Englishmen had come to the Massachusetts colony and twenty villages on or near the bay had been founded. So great was the tide of immigration that Charles I in Council issued an order in February, 1633, to prevent it. The early settlers' houses, in John Perkins' day, were not, as commonly supposed, of hewn logs nor boulder stone but were extremely primitive huts built of peeled bark with thatched roofs and one large door which served for both entry and light. These one room dwellings were for long called "English wigwams." The great open fireplace with its large chimney was entirely built of crossed sticks bedded in clay, of which substance was also made both the hearth and the floor. Soon after 1631 thatched roofs and wooden chimneys on all new houses were banned by the colonial legislature as a fire preventive measure. There was at first a great dearth of iron implements and utensils, and wrought iron nails for building were practically unknown before 1650. Almost everything about the settlers' homes was made of wood, leather or horn. Of the wealthy immigrants little need be said for they were better able financially to bring with them or to import from England, all the extra comforts they needed. By 1660, stone, slate and brick made in the colonies had largely displaced wood for all public buildings. Ipswich, one of the three shire towns of Essex County, was built on a small river named for the settlement. This made for good harbor facilities and the town soon became a port of entry for Essex County. Many dangers and persecutions must have beset the Perkins family in those early days, for the menace of the neighboring Indian tribes which culminated in a war with the Pequots in 1637, was a grim reality. One of the lesser dangers was the wolf packs from which there was no safety after dark. It is recorded in the Ipswich archives of 1642 that all householders were required to keep a mastiff, hound or beagle to be in readiness to hunt the wolves. It is also recorded in 1661 that any inhabitant of the Ipswich farming community who absented himself or his wife from public worship was liable to have his farm sold by order of the General Court "so that they may live nearer to the sanctuary and be able more conveniently to attend on its religious services." It was in the midst of such austere and primitive surroundings that the American branch of the Perkins family was founded.

was born Jacob Perkins, the inventor, the third child who was named for a previous son Jacob who had lived but a few hours.

After his marriage to Jane Dole, Matthew Perkins moved to a house in Newburyport, the location of which unfortunately is not known. Here he carried on his trade as a tailor and here his eight children were born, only three of which appear to have reached maturity. These three were Jacob, Abraham and a daughter Sarah. Of Jacob's half brothers, several were active patriots in the Revolutionary War, notably Captain Benjamin Perkins, who served first as a lieutenant in Captain Moses Nowell's company in 1775. Benjamin fought at Bunker Hill and afterward in the campaigns of New York and New Jersey, all with distinction and he was promoted to the rank of captain before the end of the war. Captain Perkins died at the comparatively early age of 48 and rests in the Old Burying Ground at Newbury.

Of the early years and the boyhood days of Jacob Perkins, very little is known. His home surroundings were of the simple order which prevailed in those early colonial times. His father was prosperous in a modest way and he was able to give his numerous children at least the security and comfort of a sound roof and an ample table. By his mother, Jacob was taught his letters and the simpler lessons she could impart to him. It has been said that Jacob had but a common school education; in this, if true, he was more fortunate than many other boys of his day and position. Schooling cost little, it is true. Indeed it amounted to but a few pence a day, generally at the home of some retired nautical martinet, minister or indigent dame, but unless the parents were willing and able to lay out these few pence, even such simple education as this would have been denied to many.

During the long hours of browsing by the authors through the files of the early newspapers of Newburyport, the following advertisement was noted, and as this seems to fit in so nearly with the educational period of young Jacob, it has been considered appropriate to quote it here:

> Joseph Atkins informs the public he still continues to teach reading, writing and arithmatic, also Navigation after the most approved methods, utility of which he has demonstrated from a large experience of 34 years at sea.
>
> N.B. He intends to open a school for young ladies next week to begin at 5 o'clock afternoon.

Jacob Perkins at the date of this notice would have been only eight years old but, considering that in four short years he was to commence the first steps of his business career, it is not improbable that this was the school which Perkins attended. Apart from this accepted road to learning, there was an even finer way for the youth of that day to obtain knowledge and that was by observation and for that there was in Newburyport at this period plenty of exciting opportunities.

The opening guns of the revolution had already been fired at near-by Lexington by the time young Perkins was nine years old. So close were the current stirring events that every rider from the South must have kept the good citizens of Newburyport in tingling suspense. For a short while, shipbuilding in the town received a great impetus. In 1776 the frigate *Boston* was built on the shore of the Merrimac River by public subscription and the progress of the work was a daily source of interest to both old and young. In the Perkins family, the occasional furloughs of Benjamin from the ranks of the embattled patriots,

with his tales of marching and fighting and cannons and guns, must have done much to stimulate young Jacob's imagination and desire to also take a more active part in the greater things of life.

By 1778 Newburyport was feeling the suffocating effects of the prolonged war. Shipping lay useless in the river, as practically all of the able-bodied men and youths had marched southward. Jacob Perkins was now twelve years of age, he was on the threshold, behind him complacent boyhood, before him a man's career. The time had come for him to learn a trade. His parents no doubt thought young Jacob had acquired enough schooling from books to prepare him for the more serious things of life. The trade chosen for Jacob was that of a goldsmith and it may be assumed that this was Jacob's own occupational choice for he did not fancy following in his father's trade of tailoring, preferring some outlet for his pronounced mechanical leanings, which were as yet untried for lack of suitable opportunity. At Newburyport at this time there were several master craftsmen following this profession. Of these were Joseph Moulton and Edward Davis, who were well established at the commencement of the Revolutionary War. Davis had his shop close to Market Square, and according to Belknap's *Artists and Craftsmen of Essex County*, his business also included watch and clockmaking as well as gold and silversmithing. In 1778 young Jacob entered upon his long apprenticeship with Davis which would have in the ordinary course of events expired in 1785, "during which term said Apprentice his Master faithfully shall serve, his secrets keep, lawful commands everywhere gladly do." The money considerations involved in this apprenticeship are not known. Perhaps it was that Davis was a confrere or good neighbor of Matthew Perkins and was thus happy to oblige an old friend by taking one of his sons into his home and shop to learn the arts and crafts of his highly skilled trade.

Silver marks (enlarged) of Edward Davis and Jacob Perkins,
from *The Book of Old Silver* by Seymour B. Wyler.

The chosen occupation seems to have proved both satisfactory and interesting to young Perkins. The work to be performed was more varied than the term "goldsmith" might imply. Many troublesome operations which had hitherto been performed solely by hand, the inventive genius of young Perkins overcame by some simple device or tool which greatly added to both the appearance of the article made and to the profit of his master.

In 1781 while Perkins might still be considered but little more than a boy, an event occurred which would have ended the career of one less self-possessed and capable than Perkins. This was the sudden death of Davis, which left his financial affairs and his family in a confused and precarious situation. Perkins, with only three years of his apprenticeship completed, remained the only possibility for the continuation of the business. Faced with this responsibility, as well as feeling strongly a sense of obligation to the widow of his late master, Perkins stayed on and assumed complete charge, though he was at the time only fifteen years of age.

The popularity of gold and silver hollow beads, both plain and embossed, was at that

period at its height, for it was an age of simple but substantial jewelry, "In Massachusetts, it was almost the universal custom for women to wear gold beads, thirty-nine little hollow globes, about the size of a pea, strung on a thread and tied around the neck." [3] The tradition is that Perkins made such beads from gold and silver coins which he obtained from the sailing masters who traded with the West Indies and the Spanish and Portuguese colonies of South America. He pressed between dies each bead in two halves, either plain or embossed, and then joined these two parts together by fusion, thus producing an article of superior appearance, which was considered equal to the best imported variety. He designed and made many other articles of jewelry, using whatever gold was available, principally old Portuguese coins called "joes" and "half joes," [4] the gold content of which was pure and soft and easily rolled out into thin sheets, suitable for bead making. Silver buckles[5] made from Spanish silver dollars or "pieces of eight" [6] also found a ready sale in the near-by towns and countryside, for shoes, knee breeches and hat bands. Later when the shortage of gold came, due to the restriction on trade and the recent decision of Congress to pay off the national debt in full, Perkins devised a means of gold plating base metals, by making use of the known affinity by which dissimilar metals can replace each other by chemical reaction. This, although a remarkable achievement under the circumstances of restricted diffusion of knowledge at this period, would probably have involved the same principles as used by the early German goldsmiths, called cold or dry gilding.[7]

In the absence of any definite information of Perkins' activities during the next five years, it may be inferred that he continued to work at the jewelry trade. After peace was signed at Paris in September of 1783, the commerce of Newburyport began to revive. From 1783 to 1794 it is recorded that [8] "vessels arrived in large numbers from Guadaloupe, Port au Prince, Surinam, and Martinico, with cargoes of molasses, sugar, coffee and cotton and from Europe came linen from Rotterdam, salt from Ireland, and gunpowder from Dun-

[3] *Historic Dress in America,* by Elizabeth McClelland, 1910, Part II, p. 217.

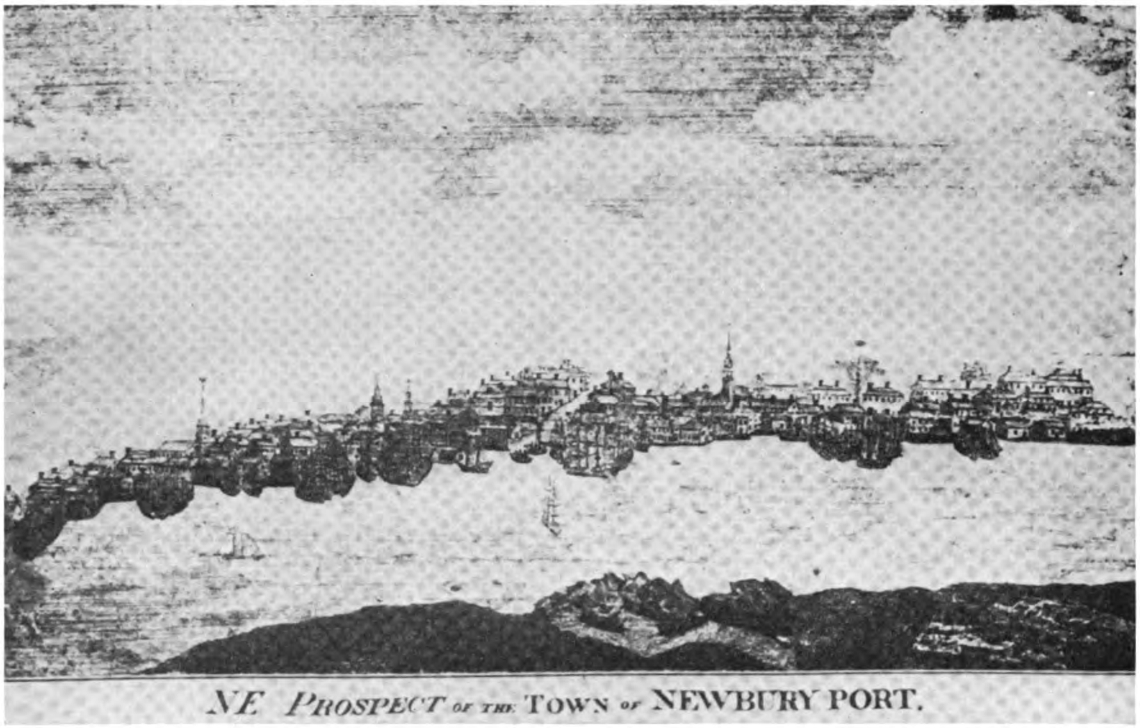
[4] Before the establishment of the United States Mint at Philadelphia in 1792, a great variety of foreign coins had circulated in the American colonies. Among these was the "Dobra" or double Johannes gold piece bearing the head of John V of Portugal, issued between 1782 and 1835. There also circulated a smaller Johannes gold coin commonly called a "half Joe." This was worth 12800 reis or the equivalent of about $8.81. These coins supplied most of the jewelers of the period with the gold requirements of their trade.

[5] The buckle came into fashion in Europe after 1666 and lasted until about 1792. Silver and plated gold buckles were principally used on shoes, but with the advent of the shoe string, they gradually went out of style, to the ruination of what had been a lucrative industry. America appears to have wholly discarded buckles as a means of adornment by 1800.

[6] The Spanish milled dollar was long recognized by reason of its standard of fineness as legal payment all through the American colonies. After the Revolution, the Continental Congress promised to pay its obligations in this coin. Massachusetts at an early date coined money from silver taken in trade with the buccaneers of the Spanish West Indies. The first shilling, sixpence and three penny pieces were merely stamped N.E. on one side and a denominating Roman numeral on the reverse. To prevent fraud, the General Court ordered, in 1651, a new and elaborate design stamped on both sides of the coins, an example of which is the Pine tree shilling of 1652.

[7] This form of gilding was accomplished by steeping linen rags in an acid solution of gold made by dissolving the precious metal in Aqua Regis (hydrochloric and nitric acid). The rags were then burned and the ashes moistened with salt water, after which they were rubbed onto the articles to be plated. This method is cited by Robert Southwell in the *Philosophical Transactions* for 1698, but the process is not durable owing to the microscopic thickness of the plating. There have been various chemical baths devised for depositing silver and gold, known as the "immersion process," but all have the same lack of permanence. Only by electro-plating (1840) has unlimited thickness of deposited surface been possible.

[8] Currier's *History of Newburyport.*



From *History of Newburyport*

Copy from an oil painting by Benjamin Tucker. *Circa*, 1796.

Spanish Silver Dollar.

A Portuguese Gold Half "Joe."

Coins from which Jacob Perkins Manufactured Shoe Buckles and Hollow Gold Beads.

Reproduction of these coins through the courtesy of The Chase National Bank, New York.

kirk." With the increased prosperity of Newburyport, Perkins' finances must have improved considerably. He still managed, or perhaps owned in part, the business of his late master in Market Square, though of the actual circumstances of this there is no recorded confirmation.

The next incident of importance in Perkins' career is in connection with the issue of the early Massachusetts copper coinage. By 1785 the growing need for a more abundant circulation of coinage as a necessity of inter-state trade was definitely voiced by the people of Massachusetts. At a meeting of the Assembly on July 18, 1786, some of the legislators urged the governor to inquire[9] "whether Massachusetts can be supplied with copper and silver coin struck at the United States Mint and when it will commence operation." The Federal Government was, however, not quite ready to comply with this demand and the Assembly became impatient. It was a difficult and unsettled period in national affairs, for at this time there had not as yet been an election for president, there was no United States court and Congress found itself with no money and little authority. Massachusetts being in urgent need of specie currency and not being willing to wait on the pleasure of the Federal mint, then only in process of formation, decided to have its own coinage forthwith.

Drawing of the Massachusetts Copper Cent of 1788, showing the closed SS in the Perkins Dies.

The Assembly therefore voted that a State Mint with Ebenezer Hancock as Mintmaster be established for issuing copper, silver and gold money. The first coin authorized were cents and half cents to the value of $70,000, to be made as soon as practical. The plan met with unexpected delays, however, and it was not until May, 1787, that Joshua Witherle was appointed superintendent and was empowered to have the necessary buildings erected and to install machinery, rolls and presses. Part of these works were on Boston Neck and the rest at Dedham, ten miles south of Boston. Several persons were employed to submit designs and make the dies, among them Joshua Witherle and Joseph Callender of Boston, attempted this work. The first design made was discarded, the dies themselves proving unsatisfactory. The art of making coin dies is to raise and depress the metal blank on both sides harmoniously or the dies will be subject to undue strain in certain places and will break. A problem now, as it was yesterday, for both artist and engineer. It was here that the skill and knowledge of diemaking obtained in his trade as a goldsmith, enabled Perkins to succeed where others appear to have failed. The design for the Massachusetts cent[10] as finally adopted, is shown above. On one side is the American eagle, a shield on its breast and on the

[9] *Historical Account of Massachusetts Currency*, by Joseph B. Felt, Boston, 1839.

[10] The first design had on one side thirteen circles linked together, a small circle in the middle with the words "United States" round it and in the center "We are one." On the reverse side was an hour dial and "fugio" on the left. On the right was a meridian sun above the dial and below the words "Mind your business." This copper coin was dated 1787 and was not continued.

other an Indian with bow and arrow in his hand, which emblem formed part of the original seal of the Massachusetts Bay Colony. After this design was approved, several artisans went to work producing the dies for use at the new Mint. Joseph Callender, who was a professional die sinker, had offered to make the dies at £1-4 each, which was considered very costly and it was decided to find a cheaper engraver as soon as one could be found capable of the work. This was soon done in the person of young Jacob Perkins, who was to receive as payment for his work one per cent of the coins struck from his own dies. However, Callender seems to have been the principal diemaker for this short-lived coinage as he received a total of £48-12 for thirty-nine new dies and repairs to three others while Perkins seems to have received only £3-18-10, which was paid in three sums during 1788,[11] one payment taken from the Mint Records[12] was for "19 shillings for die sinking—September 30th, 1788." There are at least six known varieties of the Perkins cents, this being due to slight alterations in the individual cutting of the dies. The most distinguishing marks of these cents are the SS in Massachusetts being closed as if by a diagonal line. A characteristic of these Massachusetts coins was that they were milled around the borders but were plain and smooth on the edges and the indications are that the milling was a part of the die work and was not afterward indented by a machine. It does not seem as if the Perkins dies were used until the beginning of 1788 and by then the Assembly was getting uneasy as to the legality of doing their own coining.

The revision of the Articles of Confederation, adopted September 17, 1787, at Philadelphia, strengthened the hand of the Government, at least morally, and before long it exerted its prerogative of being the only constituted power to mint coins in the United States. This caused Massachusetts to hastily use up all the stocks of copper that were on hand by a further issue of one half cent and one cent coins bearing the date of 1788. After which the workmen were all discharged and the Mint was closed down. In all, only a few thousand dollars of this copper coinage was manufactured and Perkins received but little out of this numismatic venture except reputation.

Perkins, though considered a good engraver, does not appear to have executed much in the way of die sinking. The best known of his work was a pattern silver dollar which he made in 1793, which shows a bust of Washington in military uniform facing left and around the field is some very fine engine work of intricate pattern. The sample design was struck on a thin piece of silver, only one-fifth the thickness of a regular dollar coin.[13] Perkins also engraved two mortuary medals with a raised design of the head of Washington which were reproduced in silver and copper-gilt and worn in the processions honoring Washington

---

[11] These payments mentioned in *The Early Coins of America*, by Silvester S. Crosby, Boston, 1878.

[12] Record in the Taylor Collection, of the American Antiquarian Society.

[13] This unique specimen of Perkins' early work passed into the possession of Matthew Adams Stickney, the collector who in the *American Journal of Numismatics*, Vol. 3, No. 5, 1868, says: "A silver pattern for the first coinage of the United States dollars beautifully executed by J. Perkins of Newburyport and obtained by me from his nephew, which last was not accepted by the Government because it bore the medallion head of George Washington, a too aristocratic design for a period governed by French influence." The nephew mentioned was no doubt Nathanial Perkins, son and business partner of Abraham Perkins. From J. Russell's *Gazette*, Boston, January 6, 1800, the following may be quoted: "Mr. Jacob Perkins of Newburyport, has designed and executed a very beautiful medal of General Washington. On one side is an excellent likeness of that illustrious personage; and on the reverse, a memoranda of the most remarkable periods of his life. They are struck off on gold, silver or white metal and may be purchased of Mr. Perkins, or at the bookstore in Newburyport and of Mr. Eben Moulton, goldsmith, in this town."

after his death.[14] It is interesting to note that the Masonic Order of Boston held a magnificent funeral procession in token of national mourning on January 11, 1800, at which the Reverend William Bentley of Salem preached the memorial sermon and afterward he was invited, with others, to supper by Paul Revere, the celebrated silversmith and patriot. Included in this gathering was Jacob Perkins, concerning whom the Reverend Bentley wrote in his diary "and also present was Mr. Perkins so imminent for his mechanic genius and on this occasion so well known by his excellent medals of our General Washington."

Perkins is also credited with making the dies for several types of military buttons at this period, but his principal die work was for jewelry, buckles and similar articles of adornment but no examples of these appear to have survived. A notice found in the *Essex Journal* indicates the extent of one branch of Perkins' business, that of buckle manufacturing during the year 1793:

APPRENTICES WANTED.

Two or three stout active lads 14, 16 years old, wanted as Apprentices to the BUCKLE MAKING business by

JACOB PERKINS.

The few pounds which Perkins had earned by making coin dies for his native state were negligible and Perkins was again engaged in his regular business, but with his mind much occupied with what he had recently observed at the State Mint and its hastily organized equipment. He remembered the slow and clumsy fly press which required at least four men to swing the fly arms and another man to attend to the stamping of the discs, which in turn had to be passed under another press to make the impressions. He thought of the broken dies due to the misplacing of the blanks and the labor of making new ones—much wasted energy that produced very little at the end of an arduous day. Everywhere it was the same, handwork, hand tools, no two things alike not even two nails. So must have reasoned young Perkins and within him the urge to create more practical methods was born.

In 1790, on November 11, Jacob Perkins married Miss Hannah Greenleaf of Newburyport. Perkins was then twenty-four years of age and Miss Greenleaf was almost twenty. This young lady belonged to a substantial and much respected family of the town, whose forebears had settled there in 1635. On February 7, 1792, their first child was born, a girl named for her mother, Hannah Greenleaf.

Some four years had now passed since the closing of the Massachusetts Mint and during that time Perkins had occupied his spare time in experimenting and in building two machines. One was a coining press to complete a piece of money with one operation; and the other a machine for cutting and heading nails. These machines were somewhat akin to each other, for both were planned to perform quickly a troublesome piece of repetition work.

On June 6, 1792, there appeared in the *Essex Journal* a notice of the new Act to

[14] The original steel dies for these medals are still in existence. One, an oval die, is in the Taylor Collection of the American Antiquarian Society at Worcester, and the other is owned by Miss Adelaide W. Currier, of Newburyport, great granddaughter of Lieut. Aaron Pardee, who married Jacob Perkins' sister Jane. This latter die is circular and the head of Washington is surrounded by the words "Geo Washington born Virginia Feb. 22 1732."

MAP I

A map of a part of Massachusetts and New Hampshire, with place names referred to in the text. *Drawing by the authors.*

provide the nation with copper money and no doubt this immediately caught Perkins' eye. George Washington approved this act earlier in the year on May 8, and the first United States Mint was put under construction in Philadelphia in the following July. Perkins' work for the late Massachusetts Mint was well remembered and many of his associates of both Boston and Newburyport urged him to apply for a position in the new Federal Mint. An editorial in the *Essex Journal* of July 18, 1792, said:

> Several newspapers of the past and present week have prematurely mentioned Mr. Perkins of this town being sent for to Philadelphia, for the purpose of suprintending the coinage there. Mr. Perkins' abilities in that line are fully adequate to such an appointment as the specimens he has exhibited in that line amply testify. Instead of the former method of performing the business, he invented a new machine, which cuts the metal into such circular pieces as are wanted, and gives the impression at the same time.—its motion is excelerated by a balance-wheel, and more than one-third of the time and labor thereby saved. He has also constructed another machine, of his own invention, for milling or lettering the edge, by which a boy can mill sixty a minute, were it found necessary, he could apply steam to perform all the most laborious part of the business. But what is of more importance, and will be found to be of more public utility than the foregoing, is a check which he has invented, for discovering counterfeits—this is so contrived, as that one-eighth of a minute is sufficient to determine, without the possibility of a mistake, whether a piece of money is genuine or not, and any town or merchant can be supplied at a small expense with said checks, and then rest assured that an imposition will be absolutely impossible.

This newspaper notice conveys a fairly clear impression of the Perkins coining press, for by turning a crank handle a heavy fly wheel was set in motion which operated a lever to punch out the blank and without pause of motion, impressed the design between two dies. The milling or knurling of the edges of the coins was not entirely new[15] perhaps, but for this to be done rapidly on a machine was a decided mechanical innovation.

There is also mentioned in this editorial, Perkins' check protector for the detection of forgery of paper money. This is the first mention of this invention which, however, was not patented until 1799 and which will be referred to in detail later on.

Perkins no doubt was greatly excited at the possibility of obtaining an appointment under the Federal Government at the new Philadelphia Mint; a position which he was indubitably well qualified to fill. He decided that a personal application in Philadelphia was essential. The difficulties and expense of travel by road at this period induced Perkins to go to Philadelphia by water. The sloop *Dove* made regular sailings from Hooper's Wharf, with passengers and freight, between Newburyport and Philadelphia, and it is probable that Perkins took passage on this boat sometime in July in 1792. He carried with him, in addition to samples of his die making skill, a letter of introduction from the Reverend Jonathan Murry to Dr. Benjamin Rush[16] of Philadelphia. Dr. Rush was an intimate friend of David Rittenhouse,[17] the newly appointed director of the United States Mint, and it was hoped that Dr. Rush's influence would induce Rittenhouse to place Perkins in a lucrative

[15] First introduced to prevent clipping and filing of the edges of coins by Simon the English engraver at the Royal Mint in 1650. In 1685 a machine was invented by M. Casting at the French Mint and was soon after adopted by all European mints. The French knurling machine "pour la Marque sur Tranche" rolled the coins between two serrated strips of steel on a horizontal table.

[16] Dr. Benjamin Rush, 1745-1813, celebrated physician and educator, was made treasurer of the United States Mint in 1799.

[17] David Rittenhouse, 1732-1796, astronomer, was director of the first United States Mint. He served for three years.

position in the Mint, as a die sinker or in some similar capacity. The Reverend Murry's kindly but floridly verbose letter to Dr. Rush reads in part as follows:

Newbury Port
July 11 1792

Although I have sent forward several letters to trouble you in the course of last winter, to which I have received no reply: . . . . [here follows a long discourse on the writer's bodily ailments]. My young friend, Mr. Jacob Perkins, the bearer hereof; whom I wish with the most ardent affection, now to introduce to your acquaintance and recommend to your patronage and friendly regard. At the call of his country he quits a most desirable circle of relatives, to all of whom his temper and counsel have peculiarly endeared him from his earliest youth to the present day. He goes by desire of some principal members of Congress, to offer himself to Mr. Rittenhouse, candidate for an important department in the National Mint. His genius in the line of his profession your superior descernment will quickly discover; but you will give me leave to say that, if unaffected modesty, easy manners, and unblemished life and generous expansion of mind, can deserve the candid attention of the most most liberal friends of arts of virtue and of country he will not fail to secure a place in your bosom . . . . and let me that every instance of friendship you may be pleased to discover towards him shall be recorded on the tables of my heart, as if they had been personally bestowed on myself, who with every sentiment of gratitude and esteem still remains your obliged and affectionate friend and most

Obedient servant,
Jno. Murry

Dr. Rush.

In spite of the fact that in this letter young Perkins is painted as a paragon of all the virtues, the appointment was not forthcoming. It is probable that long before his arrival in Philadelphia to apply for the position, Rittenhouse had completed the whole personnel of the Mint and there were no vacancies left. There is also a possibility that Perkins' ideas on coin machinery were considered too radical and untried for a government enterprise, for it is a fact that for the next twenty-five years work at the Federal Mint in Philadelphia was carried on in practically the same laborious way as had been used in the mint of Massachusetts.

Perkins returned home to Newburyport in October disappointed over his failure in Philadelphia but not cast down. If the coining machine was not to be adopted, there was still his nail machine to be developed. Even the most humble artisan could appreciate the value of such an invention as this and cheap nails would be sure to find a ready market in an expanding country where everything had to be individually made by hand.

In a speech in Congress by Fisher Ames[18] in 1788, he said "It has become common for the country people of Massachusetts to erect small forges in their chimney corners; and in winter, and in the evenings, when little other work can be done, great quantities of nails are made, even by children. These people take the rod iron of the merchant and return him the nails and in consequence of this easy mode of barter, the manufacture is prodigiously great." The manufacture of handmade tacks was also a New England household industry during the eighteenth century, a small anvil served to beat the wire or strip of iron into shape. A vise worked by foot then clutched it between jaws which were furnished

[18] Fisher Ames, statesman, 1758-1808, born in Dedham, Massachusetts, was elected representative in the State Legislature in 1788 and member of the First Congress the same year and served eight years.

with a gauge to regulate the length of the tack leaving a certain portion projecting which, when beaten flat by a hammer, formed the head. By this laborious process a man might make perhaps two thousand tacks at the end of a long day. A few ingenious men had applied various simple devices from time to time to reduce the labor of tack and nail making but these methods did not materially increase either the finish or the output. The shortage of nails in the colonies was always pressing and most of the supply had to be imported. It is recorded that in 1776 the construction of barracks and other buildings in New York and New Jersey was so seriously delayed through the scarcity of nails that the General Court of the province of Massachusetts Bay ordered a prize vessel then lying in Newburyport and not as yet condemned,[19] "be so far unloaded as to take out of her such quantity of nails as will be sufficient to answer the present urgent call from General Schuyler." Nails indeed were so valuable in the early days that settlers who were about to remove to distant parts of the country preferred to burn down their houses and barns and thus recover the nails, rather than leave such assets behind them. This acute condition prevailed until at least 1800, but by then several ingenious mechanics had turned their attention to inventing machinery which would be both automatic in operation and applicable to being worked by water power.

The credit for having made the first semi-automatic nail machine is shared by several men, among whom was Benjamin Cochran, a shopmate of Eli Whitney, of cotton gin fame, about the year 1790. The first patent for a nail-making machine was registered at the United States Patent Office in 1791 by Samuel Briggs and his son, of Philadelphia. A model of their machine was made and deposited with the State of Pennsylvania, but it does not appear to have ever been tried out commercially. In New York Josiah G. Pierson patented a nail-cutting machine in March, 1795, but this was not placed in operation at Hampstead, Rock Island County, New York, until 1799.[20] There is a vast difference between taking out a patent for a device and commercially utilizing its possibilities. The Perkins machine was in active production by 1795 and it may be conceded that these nails were the first to be factory made.

Perkins seemed to have turned his own attention to this problem soon after 1791 and his experiments at Newburyport for the next few years occupied most of his spare time. His first machine only sheared the nails to length, the heading being performed by a separate operation. After the first experimental model had shown sufficient promise, he required more room as well as power to prove its efficiency.

In 1793 there had been established on the falls of the Parker River at Byfield, six miles from Newburyport, a woolen mill which was the first to be incorporated in Massachusetts for this kind of manufacture. Hitherto the weaving of cotton, flax and wool had been a more or less home industry. Though the promoters of this mill were mostly citizens of Amesbury and Newburyport, there were among them two Englishmen, Samuel Guppy, at this time a resident of New York, and John Warren Armstrong of Bristol, England. The machinery for this mill is said to have been made in Newburyport by a mechanic named Strandring under the direction of Guppy and Armstrong, and it is more than possible that Perkins also was employed in some capacity in its manufacture.

It is safe to say that by 1793 Perkins had got his nail machine into such shape as to

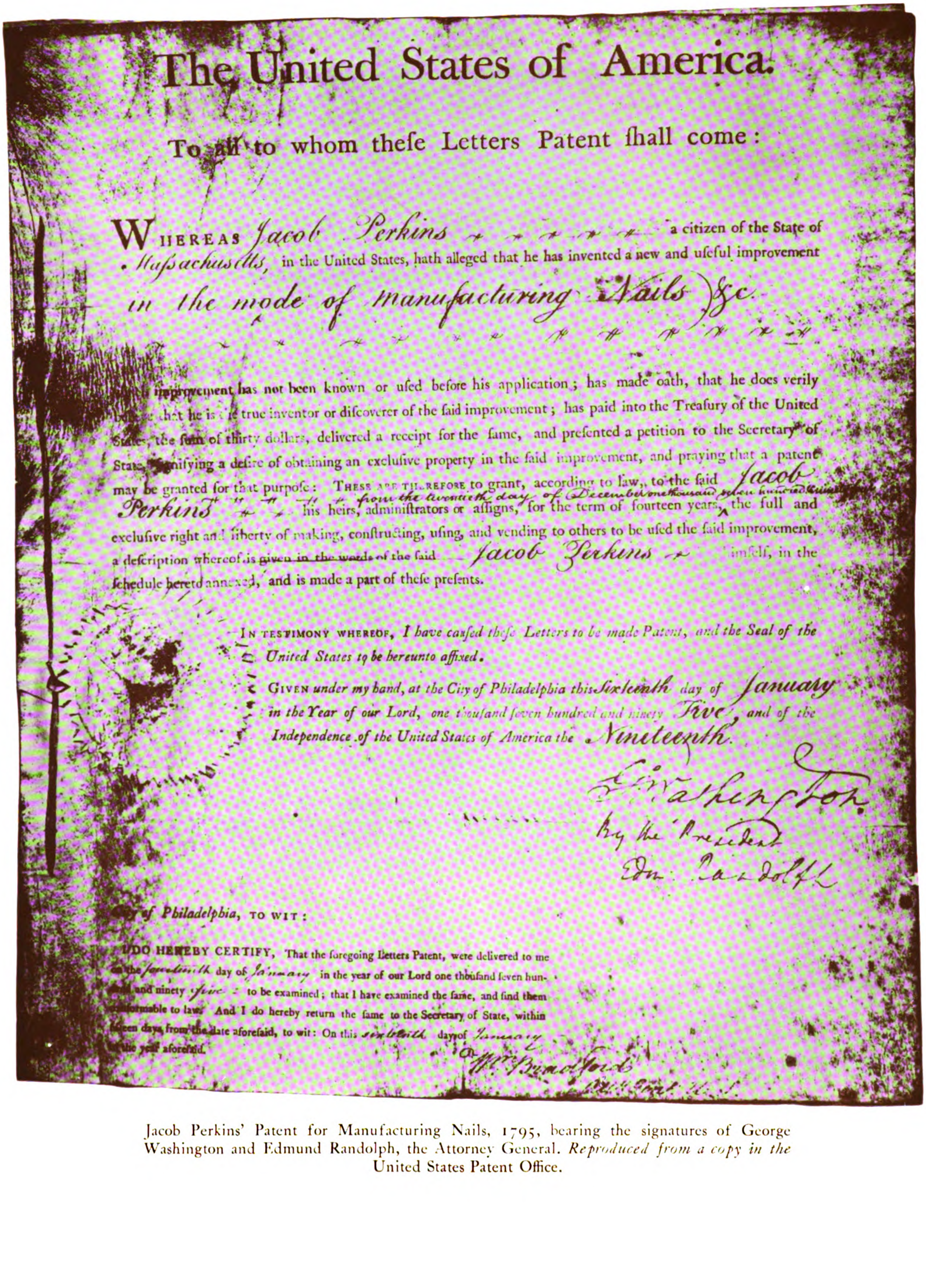
[19] Currier, *History of Newburyport.*
[20] A complete list of patentees of nail machines is given in Appendix H.

prove the possibility of manufacturing nails entirely by machinery. Armstrong was impressed and suggested to Perkins that he move to Byfield and adjacent to the woolen mill he rented a large barn from a farmer named Leonard Adams. The advantage of this change was the fact that the nail machine could be worked from the shaft of the water wheel and the production of nails could be commenced.

By 1794 Perkins had so far demonstrated the usefulness of his nail machine that he applied to the Secretary of State for exclusive protection for his invention and this was granted as from the 20th of December, 1794. The patent itself was signed by George Washington and Edmund Randolph and is dated January 16, 1795. This unique document is reproduced on Plate II. Full specifications and drawings are missing and only a brief description of the nail machine now remains as part of the original document:[21]

THE SCHEDULE referred to in these letters patent, and making part of the same, containing a description in the words of the said Jacob Perkins himself of an improvement in the mode of Manufacturing Nails etc. A short and general description of Jacob Perkins's Invention. I have invented and discovered a mode of making Nails by which much manual labor may be saved by means of an Ostrich, or revolutionary cutting Engine, and a Vulcan or heading Engine. The principle of the cutting Engine is that of a revolutionary motion i. e., a roller with 2 cutters fix'd in it ½ the circumference of the roller apart, which passing by another die in a standard or plate, cuts or presses off whatever may be placed between either of the dies on the roller, and the die in the plate, directly above which is an aperture or slit, sufficient for a piece of flat iron to pass thro'—the roller being turned in a skew shape tho' exceedingly true, acts also as a guide to the shifting plate, and brings it in that direction with each die in the roller, so as to cut up the whole strip of iron without any manual assistance, after it is once put in the aperture of the shifting plate—the heading Engine is worked by the revolution of a tappet wheel, having three tappets, each of which lifts up a hammer, which gives three strokes each revolution of the wheel, on the nail which is fixed in a vise directly under the hammer, the three strokes forming the head of the nail; there is also affixed to the tappet wheel, a piece in a curv'd form, which catching the tail of a lever forces the jaws of the vise so as to take hold the nail sufficiently firm for the purpose of heading it; when the curv'd piece ceases to operate on the vise-lever, a spring pulls open the vise, between which time, and the tappets again catching the tail of the lever, another nail is put in, the headed nail dropping down immediately on the jaws of the vise opening. It is to be observed one cutting Engine may with ease be drove by water 250 revolutions in a minute each revolution produces 2 nails and one Boy of ten or twelve years of age can with ease supply six Engines so that the labor of one Boy can cut *three thousand* Nails per minute, the heading Engine will head sixty nails per minute, by the assistance of one Boy, or more if it was possible for the Boy to hand them—a more particular description of these Engines is given in the specifications accompanied with drawings and written references herewith presented. And I the said Jacob Perkins do now certify that this Schedule contains a short and

[21] The original patent document was owned by Mr. Charles Peacock, of New York, and was loaned to Mr. Finnis D. Morris, Chief of Division E, United States Patent Office. A photographic copy of this document was then made in 1911, which is reproduced in this volume. Of the 19 patents filed by Jacob Perkins in America between the years 1795 and 1819, all but the record of their dates (see Appendix I) and subject matter have disappeared. If any specifications do exist, they cannot now be traced. After the fire at the Patent Office in 1836, many of the patents whose specifications had been destroyed were restored by a method of copying from duplicates then in existence. These patents so copied have never been placed in print and are stored in Manuscript volumes under the title of "Restored Patents" but as it may be well understood, these records must be very incomplete. Perkins lived until 1849, but it does not seem that he made any effort to have the patent specifications of his earlier inventions replaced on file. It has been thought of interest to give some account here of the disastrous fire at the Patent Office in 1836 owing to the frequent mention made by the authors both in this book and in other volumes, that certain patent specifications are no longer in existence. The official account of the Patent Office fire is given in Appendix A. In this report there is mention of a model of Perkins' nail machine, which was also destroyed.



The United States of America.

To all to whom theſe Letters Patent ſhall come:

Whereas Jacob Perkins a citizen of the State of Maſſachuſetts, in the United States, hath alleged that he has invented a new and uſeful improvement in the mode of manufacturing Nails &c.

which improvement has not been known or uſed before his application; has made oath, that he does verily believe that he is the true inventor or diſcoverer of the ſaid improvement; has paid into the Treaſury of the United States, the ſum of thirty dollars, delivered a receipt for the ſame, and preſented a petition to the Secretary of State, ſignifying a deſire of obtaining an excluſive property in the ſaid improvement, and praying that a patent may be granted for that purpoſe: These are therefore to grant, according to law, to the ſaid Jacob Perkins his heirs, adminiſtrators or aſſigns, for the term of fourteen years, from the twentieth day of December one thousand seven hundred ninety the full and excluſive right and liberty of making, conſtructing, uſing, and vending to others to be uſed the ſaid improvement, a deſcription whereof is given in the words of the ſaid Jacob Perkins himſelf, in the ſchedule hereto annexed, and is made a part of theſe preſents.

In testimony whereof, *I have cauſed theſe Letters to be made Patent, and the Seal of the United States to be hereunto affixed.*

Given *under my hand, at the City of Philadelphia this* Sixteenth *day of* January *in the Year of our Lord, one thouſand ſeven hundred and ninety* Five, *and of the Independence of the United States of America the* Nineteenth.

G^o Washington
By the President
Edm. Randolph

City of Philadelphia, to wit:

I do hereby certify, That the foregoing Letters Patent, were delivered to me on the fourteenth day of January in the year of our Lord one thouſand ſeven hundred and ninety five to be examined; that I have examined the ſame, and find them conformable to law. And I do hereby return the ſame to the Secretary of State, within fifteen days from the date aforeſaid, to wit: On this sixteenth day of January in the year aforeſaid.

Wm. Bradford

Jacob Perkins' Patent for Manufacturing Nails, 1795, bearing the signatures of George Washington and Edmund Randolph, the Attorney General. *Reproduced from a copy in the United States Patent Office.*

general description of my invention as specified in the petition by me presented to the Secretary of State praying that letters patent may issue for the same according to the law.

Witnesses Jacob Perkins.
Sam'l Coates
Edw'd W. Shoemaker

The shearing engine, termed an ostrich, evidently from the motion of burying its cutting head down through the nail plate, cut the tapering shives without the attendant having to turn the plate over after each cut as was usual on ordinary shearing machines. The difference between the number of nails that could be cut in a minute seemed out of all proportion to the number which could be headed, which was about eight to one. The first nails which were advertised to the public were apparently headless brads which required only cutting to shape them.

Soon after Perkins had applied for his patent, a business agreement was entered into between Perkins, Guppy and Armstrong[22] for the manufacture of nails commercially and also for the building of further machines for sale to the iron trade at a profitable advantage. There is no evidence to show that Perkins was, in the beginning, a full partner in this combination. It is more probable that he received a royalty on each nail machine sold and that he also drew certain profits from the marketing of the nails. By 1798, Guppy had apparently withdrawn from active interest in the enterprise and for a brief period the firm assumed the name of Armstrong and Perkins. The first advertisement of the nail business announcing the manufacture of sheared brads appeared in the *Impartial Herald* of November 24, 1795, under the term of "Newbury Patent Nails." This reads as follows:

NEWBURYPORT Patent Nails

Much superior and 20% cheaper than imported nails.

The Proprietors of this Concern beg leave to inform the importer of nails from Europe, they have begun making Brads, and will have a considerable number for all, in 14 or 20 days from this date; supplies of which will be forwarded to the Principle Ports on the Continent, and due notice given in the Newspapers. They have the fullest confidence of the superiority of their Brads to any ever imported from Europe or elsewhere, and only solicit a fair and impartial trial. Those who have made a trial, prefer them to any they ever used; those who have not tried them, they beg leave to observe, their superiority to English wrought Brads consist in their being quite regular in their shape, so much so that ten thousand may be drawn through the thinest pine without using a brad awl, or splitting the wood. Their superiority to other cut nails consists in their being cut with the grain of the iron, where as others are cut across the grain, consequently these are much tougher, and in general, will clench equal to any wrought brads.

[22] Samuel Guppy's profession is obscure but there is some indication that he was a millwright versed in textile machinery and that he originally came from Bristol, England. On August 19, 1796, he patented Perkins' nail machine in England and a supplementary patent on this was taken out by him on December 19, 1804. Just why the British patents were in Guppy's name alone is not clear. Guppy on his return to Bristol, soon after 1800, apparently did not develop these patents further. In Hebert's *Encyclopaedia* for 1836 under "Nails," Guppy of Bristol is given as an early manufacturer of patent copper nails for sheathing ships. Thomas Richard Guppy, a noted engineer of Bristol, who constructed the engines for the *Great Britain* in 1839, was probably a son or nephew of Samuel Guppy. John Warren Armstrong was a wealthy wool merchant of Bristol and had come to America about 1790 and settled for a time in Boston where he traded extensively in shipments of wool and cotton goods between England, America and the West Indies. For the Byfield woolen mill he imported at considerable risk carders and weavers from Oldham and Saddleworth in England. Armstrong's manufacturing enterprises, however, did much to impair his fortunes and in his declining years he returned to England to permanently settle in his native town of Bristol.

As many will naturally conceive the impossibility of our making a sufficient number to supply the Continent and will therefore conceive it necessary to continue their orders to Europe, we wish to remark, that we have now in compleat working order 3 Engines, each of which (if necessary) will turn 200 thousand pr. day, making in the whole 3600 thousand weekly. That we have every reason to suppose we shall make an addition to one Engine every month, those doubtful of the fact, are invited to see the operation of the Engines at Byfield, six miles from Newburyport.

Headed nails we shall also begin to make soon, which we believe will be superior to any ever made; but we leave this to be determined by those who use nails, and of course most competent to judge.

Jacob Perkins, Inventor

Proprietors
* *
*

Guppy and Armstrong

Letters addressed to J. W. Armstrong, Boston, will be duly answered.

☞ Wanted, a quantity of American sheet iron.

N.B. A few White Smiths may have constant employ, and liberal wages.

This notice ran continuously until the new year and then ceased abruptly but carpenters had approved of the new nails and they came into immediate use. On Plate III is reproduced a handwritten prospectus setting forth the cost of the nails per ton, and also offering to sell nail machines to any prospective manufacturer wishing to engage in this business. The cost of the machines was $1700 and this amount could be paid for out of the earnings of the machine.

The necessity for having additional space for manufacturing induced Perkins to look for more commodious premises than those provided at Byfield. For this reason he purchased early in 1795 at Amesbury an old grist mill on the falls of the Powow River which was locally known as Waits Mill.[23] Later on with the settlement of other manufactories nearby, this section became known as Mills Village, Map 2. The old mill, apart from that portion occupied by the existing machinery, provided a long stone cellar in which to place the nail machines which were to be brought from Byfield. Perkins bought this mill and the surrounding ground for $800 and at once arranged with the miller to continue with the grinding of corn for him as a means of additional revenue. Nearby on the Powow River was a rolling mill built about 1710 which had without interruption continued to manufacture bar iron and nail rods and later on, sheet iron and it was from this source that Perkins had been drawing his supply of material while at Byfield. It was found, however, that the rolling mill could not produce the class of iron necessary for fine brads and Perkins' partners had been forced to the expense of importing sheet iron from England. The following letter written by Armstrong conveys the fact that some other source of supply had to be found to feed their vociferous nail machines:[24]

Mr. Robt. E. Hobart
Potts Town.

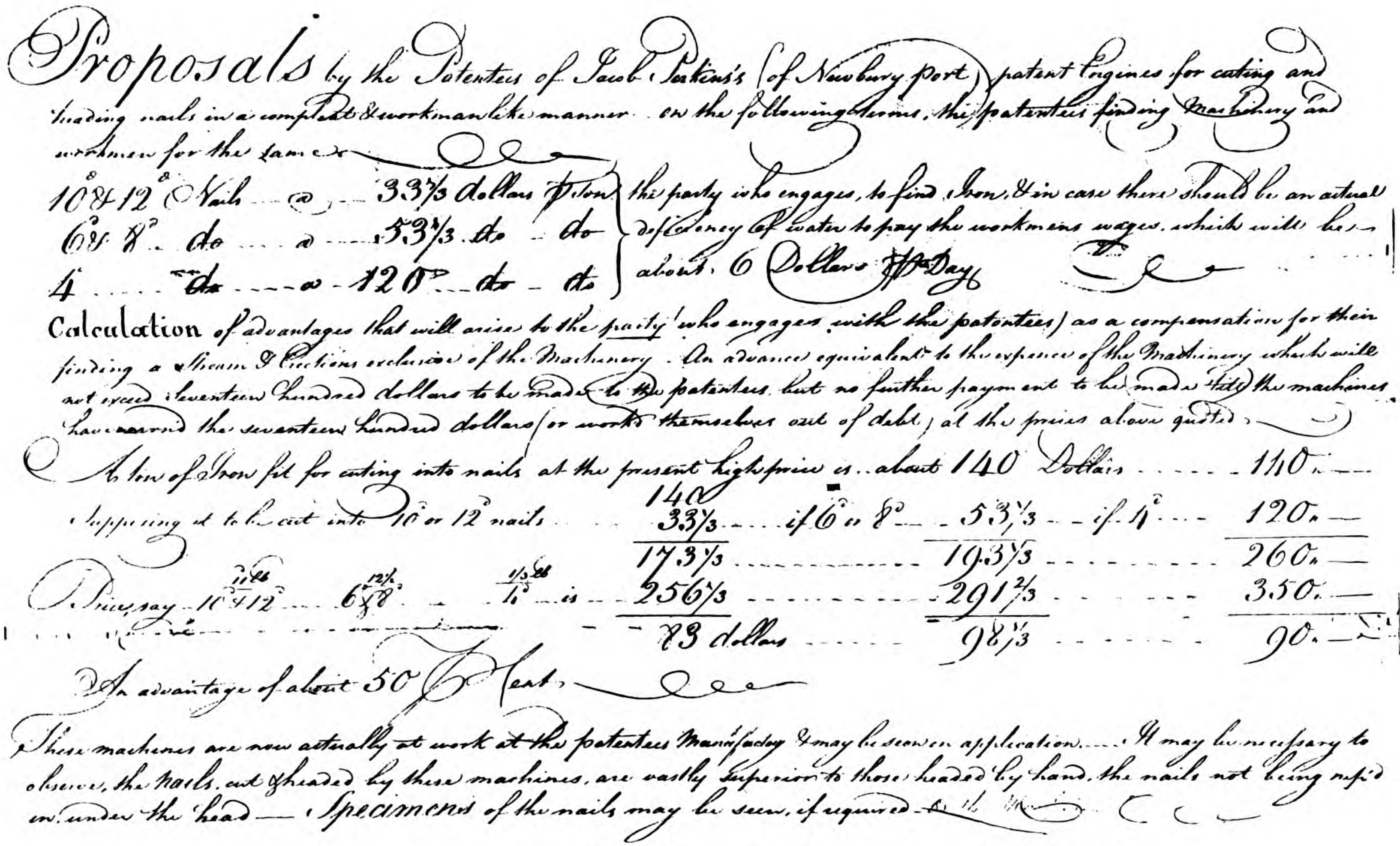
New York Dec 9th 1796

Sir

In Feby last we had some correspondence respecting Sheet Iron for making Brads, not being able to procure it in this Country, we have been obliged to import of this article largely—We have since

[23] Under Essex Deeds, Vol. CLXIV, page 95, is found the record that on February 24, 1795: "Ebenezer Stocker, Abraham Wheelwright and Ebenezer Wheelwright, directors of the Newburyport Woolen Manufactory conveyed to Jacob Perkins a lot of land with a corn mill thereon in Amesbury, known as Waits Mill, on the south bank of the Powow River."

[24] The Essex Institute, Salem, Massachusetts.



Proposals by the Potentees of Jacob Perkins's (of Newbury port) patent Engines for cutting and heading nails in a compleat & workmanlike manner — on the following terms, the patentees finding Machinery and workmen for the same —

10d & 12d Nails	@	33⅓ dollars ⅌ ton		the party who engages, to find Iron, & in case there should be an actual deficiency of water to pay the workmens wages, which will be about 6 Dollars ⅌ Day
6d & 8d do	@	53⅓ do	do	
4 do	@	120 do	do	

Calculation of advantages that will arise to the party (who engages with the patentees) as a compensation for their finding a Stream & Erections exclusive of the Machinery. — An advance equivalent to the expence of the Machinery which will not exceed seventeen hundred dollars to be made to the patentees, but no further payment to be made till the machines have earned the seventeen hundred dollars (or worked themselves out of debt) at the prices above quoted.

A ton of Iron fit for cutting into nails at the present high price is about 140 Dollars					140
Supposing it to be cut into 10d or 12d nails	140 33⅓	if 6d or 8d	53⅓	if 4d	120
	173⅓		193⅓		260
Prices say 10d & 12d 11d/lb, 6d & 8d 12½, 4d 15d is	256⅔		291⅔		350
	83 dollars		98⅓		90

An advantage of about 50 ⅌ Cent.

These machines are now actually at work at the patentees Manufactory & may be seen on application. — It may be necessary to observe, the nails cut & headed by these machines, are vastly superior to those headed by hand, the nails not being nipd in under the head — Specimens of the nails may be seen, if required.

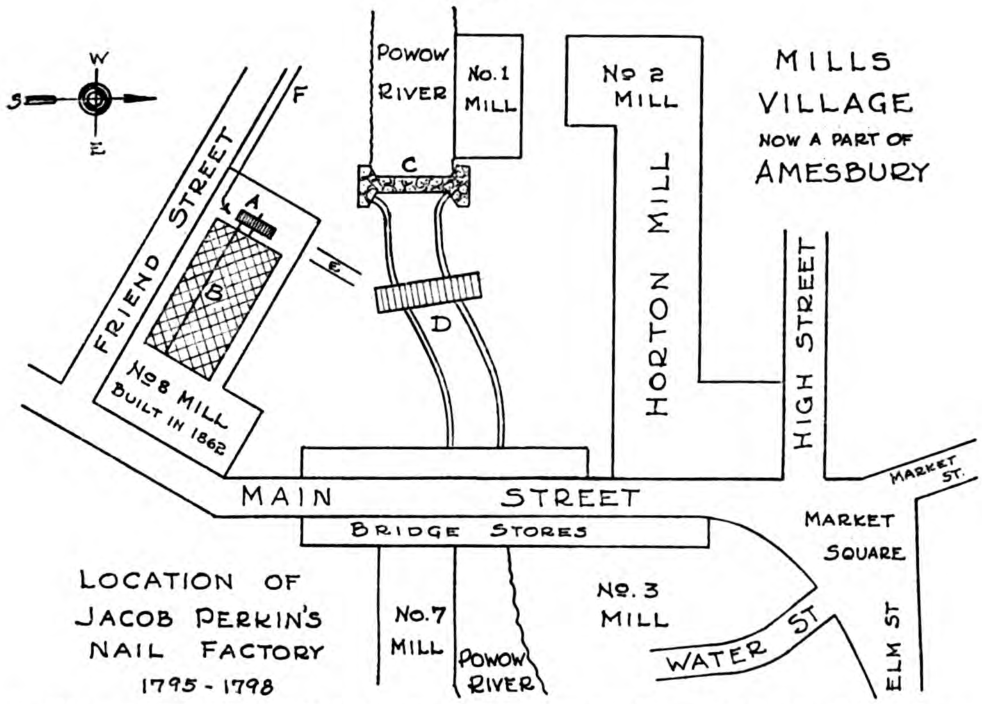
Schedule of Nail Prices enclosed with J. W. Armstrong's letter to Robert E. Hobart of Pottstown, 1796. *Reproduced by courtesy of the* Essex Institute, Salem, Massachusetts.

completed our Machinery for making Nails with as much dispatch as I believe never has been Known—conceiving from your letter of 13th of Feby last that much might be done at your works to advantage, I take the liberty of handing you our proposals having determined with Perkins the Inventor at Newbury Port on extending the use of his invention into Pennsylvania—Should you think it an object worth your attention any communications you may chuse by letter address'd to me here or through the hands of my agent Mr. C. Calloway 17 Dock Street-Phila shall meet due attention.

From Sir Your Mo, Obt svt
J. W. Armstrong

At this time Samuel Potts and Robert E. Hobart were the owners of the Vincent Slitting Mill on French Creek twelve miles below Pottstown, Pennsylvania. This iron works had been built only recently in 1793, but had already obtained a reputation for high-grade

MAP 2



A—Waterwheel. B—Site of Perkins' mill. C—The dam. D—Present bridge. E—Old tailrace. F—Probable course of intake. *Drawing by the authors.*

iron used in nail making. This fact and their situation close to tidewater which would have made transportation to Amesbury possible,[25] no doubt influenced Armstrong in this matter.

For some time the difficulty of importing iron from England had been very real. In 1793 fears began to be again entertained that another war with Great Britain was imminent. The general proceedings at this time by both England and France of seizing American

[25] Transportation by water was at this period almost the only means of conveying heavy and bulky merchandise and the utmost use was made of all available rivers and creeks throughout the country. Iron sent by water from Pennsylvania to Massachusetts would have had many miles to travel by such means. Starting at French Creek, a distance of thirty-five miles down the Schuylkill River to its junction with the Delaware at Philadelphia, the iron would then have been transhipped from the river flatboat to a deep sea schooner in which it covered some six hundred miles of open sea to Newburyport.

ships when found carrying cargoes for either country, compelled Congress to place an embargo on American vessels and international commerce was thus at a standstill for months at a time. It was not until the following year that John Jay[26] who had been sent to London specially, was able to patch things up and arrange a commercial treaty with England in November of 1794, so that the shipping of manufactured articles, including iron, could with any certainty be resumed. But with peace and safety so far assured, there was still the French frigates to be reckoned with and these pounced on all and sundry indiscriminately. But even if the ships brought in their cargoes of iron safely, there was still the new tariff to be reckoned with, recently passed by Congress in 1794, which imposed a duty of fifteen per cent on all imported wrought- and cast-iron manufactures. That Armstrong did not try nearer home for his sheet iron is strange, for at this period there were many rolling and slitting mills in Massachusetts which manufactured this class of material, although the quality might not have been equal to imported iron suitable for making small brads. Probably the true reason was that Armstrong hoped to effect a double purpose which was to get orders for the new nail machine while at the same time he dickered with the Pennsylvania ironmasters over the price of their iron.

It was soon discovered that the existing water wheel at the nail factory could not provide enough power for the increased work demanded of it and this was replaced with a larger one by Perkins in 1796. The construction and efficiency of the new wheel when completed reflected greatly to Perkins' credit and was often cited as a fine example of early American engineering. The *Technical Repository* of 1826 gives the following account of Perkins' improvements:[27]

> Mr. Perkins erected at Newburyport, [this was actually at Amesbury] a water-wheel of thirty feet in diameter, on the plan of what is termed in America a pitch-back; that is, one which receives the water near to its top, but not upon it, as in over-shot wheels; this is, indeed, the most judicious mode of laying water upon the wheel; as, in case of floods, the wheel moves in the same direction with the water, and not in the opposite one; neither is it encumbered, as in the over-shot wheel, with a useless load of water at its top, where it does nothing but add weight upon the necks or pivots of the wheel-shaft, and to the consequent loss of power by the increased friction upon them; whereas, in the pitch-back, the water is laid on at a point, where it acts by its leverage in impelling the wheel, and has yet time to become settled in the bucket, previous to its reaching the point level with the axis, where it acts with its greatest power. The wheel itself was constructed of oak, but with iron buckets; and it had a ring of teeth around it, which drove a cast iron pinion, of three feet in diameter which gave motion to three laying shafts, each of thirty feet in length, coupled together, so as to form a line of ninety feet; and from which the necessary movements were communicated to the machinery for making nails.
>
> Mr. Perkins placed his pinion as close as possible under the pen trough, which delivered the water upon the wheel; and he thus greatly lessened the weight upon the necks or gudgeons of the wheel-shaft, by suspending it, as it were, upon the pinion; whereas, had he, as is usual, placed it in a horizontal line with the axis of the wheel, and on the opposite side of it, he would have loaded the necks with a double weight; namely, the water upon one side of the wheel, and the resistence opposed by the machinery to be driven by it, on the other. He also took care that the teeth upon the wheel, and the pinion, should always be kept wet, or run in water, instead of being greased as is usual, and this he found sufficient

[26] John Jay, statesman, 1745-1829, was appointed by Washington as a special envoy to Great Britain and concluded with Lord Grenville, what is known in American history as Jay's Treaty. This treaty was denounced by the opponents of Washington as a complete surrender to England.

[27] *The Technical Repository*, Vol. VIII, which was published by Thomas Gill in London. This account also appeared in the appendix of all the later editions of Oliver Evans' *Young Mill-wright and Miller's Guide*, starting with the sixth edition of 1829 and on until the fifteenth edition in 1860.

to cause them to run smoothly and without the least noise. The motion of the wheel's periphery was about three feet per second, agreably to the improved theory, so ably demonstrated by the late scientific Mr. Smeaton; and it continued to perform its work, with great satisfaction to its owners, for ten years, when it was unfortunately destroyed by fire.

From the length given of the main drive shaft, which was 90 feet long, some idea may be gained of the size of the nail mill. The building was probably at least one hundred feet long by twenty-five or thirty feet wide. By means of the long shaft the cutting and heading levers of the individual nail machines were raised and lowered by large cam wheels.

The manufacture of various kinds of nails[28] by the Newburyport Nail Company continued without interruption during the next two years. The nails were made in two operations of the lever, practically a combination of two machines. Perkins had been experimenting for some time with the idea of overcoming the necessity of these two operations by combining the mechanism of the cutting and heading dies so that only one motion of the lever would be required, thereby greatly increasing production.

The association with Guppy and Armstrong had not proved altogether satisfactory from Perkins' standpoint. For one thing, the partners objected to the amount of time Perkins spent on experiments and improvements to the existing machinery, and still more so to the attention he gave to work on matters not akin to the business of the factory. It must be apparent that Perkins was an inventor before all else and profits which came to the firm were apt to be weaned away to develop extraneous ideas. This characteristic of Perkins ran through his whole professional career and was a frequent source of friction between him and his business associates.

By the middle of 1798 things had reached somewhat of a crisis between Perkins and his partners. The exact cause of this situation is not clear. It may have been personal disagreements over business policies or that the two elder men were not satisfied with the profits being derived from the nail making enterprise. Something of what led up to the break between Perkins and his partners has been recorded through one David Moores of Exeter in New Hampshire, who was a machinist employed by Perkins at this period. Moores stated[29] "that he knew of Perkins' machine and that he came to work in the nail factory for Mr. Perkins in December of 1797. Soon after, he said, Mr. Perkins invented and made a machine for cutting and heading nails at one operation. Moores worked upon the machine from the time it was begun until it was done and put into use, all of which was done under the immediate direction of Mr. Perkins. It was in complete operation in the following summer. After making fifty or sixty pounds of six-penny nails, Mr. Perkins found that once in a while a nail would stick in the dies, and he concluded to attempt some further improvements on the clearer. The machine was therefore taken to pieces and Moores took the stationary part of it to his viseboard, and Mr. Perkins told him that in the afternoon he

[28] The type of nail as first made by the Perkins machine was similar to the square shank Rose nail, at that time hand forged, but with the head flattened on opposite sides. Carpenters' nails have long been known as penny-nails. This term has since the fifteenth century been used to designate the size of the nail by prefixing it with a figure, such as 2-penny nail which is one inch long, to 60 penny which is six inches long. This pricing of nails indicated that in the beginning 100 nails one inch long could be bought for 2 pence or 100 six inch nails for 60 pence, all intermediate sizes in proportion. As the inevitable changes occurred in the cost of manufacturing 100 nails, the term "penny" was used only to indicate the size of the nail. Wire nails now used exclusively in the building trades, are still referred to as "penny nails" and are not bought by length.

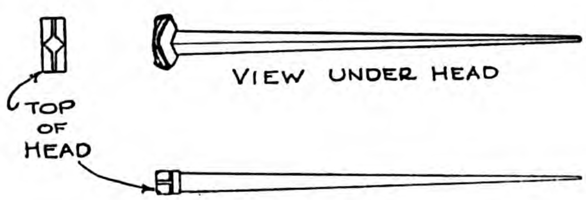
[29] From the H. J. Moulton material in the Taylor Collection of the American Antiquarian Society.

would tell him what to do with it; but in the afternoon when Mr. Perkins came in he told Moores that he had received a letter from his partners by which he was thrown out of the factory, and directed him (Moores) to throw the part of the machine which he had taken out under the viseboard, and not to put the machine together again until he requested it."

The defects of the Perkins' nail machine were brought out in some evidence submitted in a test case before Judge Washington in 1819 at Philadelphia.[30] On the respective merits of the Perkins and Reed machines,[31] it was stated in the evidence that "for want of machinery to force the piece of iron down into the gripping die, the machine would clog if an attempt were made to work it with rapidity, and on this account it would not make more than thirty or forty nails in a minute; in consequence of this defect it was altogether abandoned by Guppy and Armstrong." At the time of this hearing, the principal parts of this machine were briefly described in court as follows:

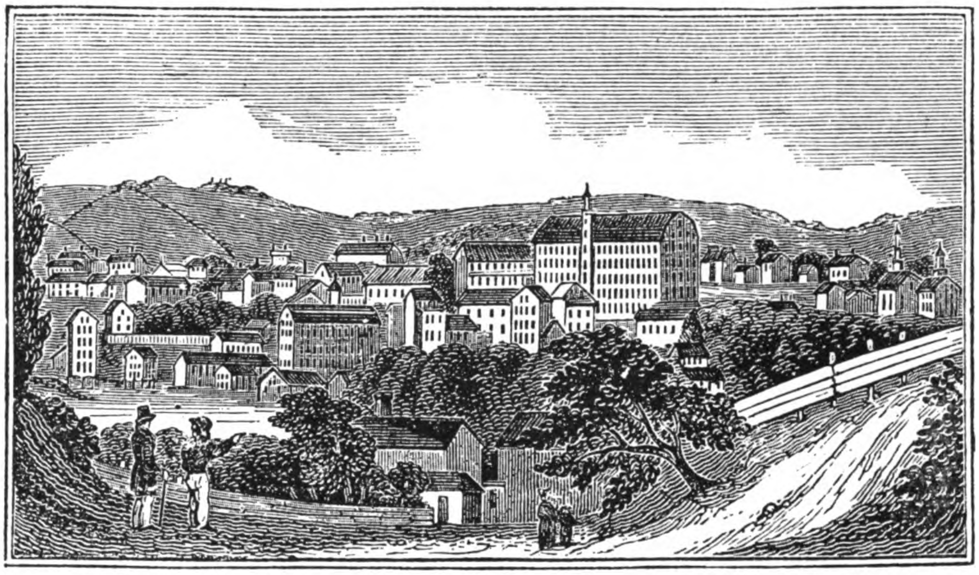
An upright and permanent jaw.
A moveable jaw in the form of a pivotted vise.
In each jaw there was a cutter to nip the nail rod to length.
A gripping die which held the nail rod until the head was made, by a set or heading die.
The power to perform this operation was by a single lever passing through a slot in the permanent jaw.
This lever acted through a toggle joint working the moveable jaw.
The first movement of the lever cut the nail rod, a further depressed movement forced up the set and formed the head.

During the years approximately from 1790 to 1798 when Perkins was endeavoring to perfect an automatic nail machine, he had in this field very little in the way of previous experience to draw upon. Inventors in plenty were his contemporaries but beyond filing their patents, little or nothing was accomplished by them in producing nails. It was in these days entirely a case of trial and error and as is usual in the case of completely new mechanical combinations, the error seemed at first to predominate. Nails made by these early Perkins machines were sheared from flat nail rods or strips of iron which were a little wider than the nail was long. To enable the grain of the nail to be in the direction of its length, the nail strips were slit across the fibers of the wrought iron plate. Many of the old Newburyport houses built at the turn of the nineteenth century must have many a pound of these Perkins machine made nails in their sturdy frames and floors. During some alterations in 1920 to the home of Miss Adelaide W. Currier, on Federal Street, which had been built in 1800 by her great grandfather Lieutenant Aaron Pardee (who was Perkins' brother-in-law), some of these early nails were extracted from a floor by the local carpenter, who remarked at the time "What funny nails." In appearance, they resembled this.

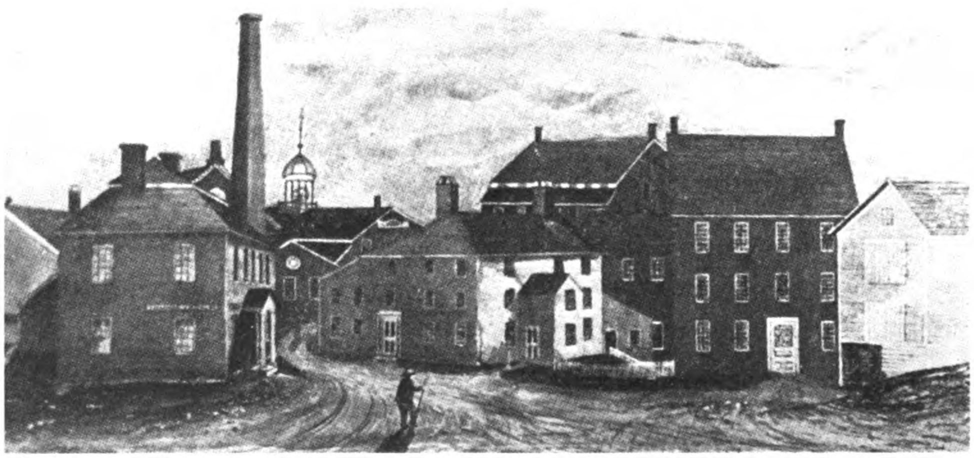


Perkins' nail of 1799.

[30] Thomas Odiorne vs. The Amesbury Nail Factory; refer to Appendix E.
[31] For Reed's Nail Machine Patents, refer to Appendix B.



Mills Village, Amesbury in 1837. From the *Historical Collections of Massachusetts.*



View of Water Street from Market Square, Amesbury, 1853. The building in the center of the background is the site of Jacob Perkins' Nail Factory. *Courtesy of* Mr. C. S. Grieves, Amesbury.

The peculiar formation of the top of the head enabled the nail to be struck with the hammer directly over the center of penetration and the flat sides aided the head to sink in flush without splintering the wood. The Perkins machine-made nails greatly resembled in this respect the 18th century French *fiches* or *fichenards*, terms used at that period to denote a large nail or spike. The nails made by Perkins' later machines had flat heads, conforming more nearly to those in use today. There is little doubt that this Perkins' nail as shown is of the period. The nails in the Pardee house could scarcely be other than Amesbury made, for in this case such nails would have been a family affair.

The Fiche or Fichenard from
Diderot's *Encyclopedie*.

A final break came between Perkins, Guppy and Armstrong on July 24, 1798, when Perkins was forced to relinquish his rights in the nail factory, including his patent of 1795, to liquidate his financial obligations to his senior partners. His second patent on the nail machine, then maturing, dated February 14, 1799, was also assigned to Armstrong, who proposed to continue with the nail factory. Under the articles of dissolution it had been agreed that Perkins was to remain on if he wished, but his position was now untenable. This disappointing and discouraging turn of events killed all enthusiasm in Perkins for further effort and so, after a few more months at the nail works, he retired and turned his attention to other enterprises then maturing. One of these was the check plate protector, an invention which was to have a far-reaching influence in national banking.

After these unhappy events, Guppy seems to have moved entirely out of the picture and the upper part of the mill was leased to a firm of wool carders and fullers. Armstrong carried on the nail-making business in a perfunctory manner until 1801 when, on December 14th, he assigned the patents with the premises to George Dodge and others who continued as the Amesbury Nail Factory.[32]

[32] The authors are indebted to Mr. C. S. Grieves of Amesbury for his communication regarding the subsequent history of the Amesbury Nail Factory. He writes: "People from out of town have been inquiring lately about the old rolling mill and nail factory that was torn down when No. 8 mill was built in 1862. One fact however is well established, that the present site of the factory now in process of construction, was the place where the first application of water power to machinery was made, and where for so many years stood the 'old rolling mill.' Jacob Perkins first introduced his machine for making nails, a branch of business which thrived for several years. The old mill in which Jacob Perkins worked was burned down in 1811, the same year as the great fire in Newburyport. This mill was soon after rebuilt, by a company composed in part of gentlemen belonging in Salem, at a time when the wealthy business men of that town were seeking investments for their great wealth in every new enterprise introduced in the State. Among them were Pascal Derby and Mr. Crowninshield and associated with them as workers were Paul Moody, Jacob Kent, Michael Morrison and a Mr. Jones. The brick part of the old building was used as the nail factory, and the stone part was used as the rolling mill. Its ancient appearance was always noticed by strangers visiting the village and with no little pride did the old citizen point to it as 'Jacob Perkins' Mill' or the old nail factory. But the water power on the stream was not long to be monopolized by saw mills or nail factories and we find that the skill of Paul Moody, Ezra Worthen and Captain Thomas Boardman was set to work in constructing a factory for the manufacture of cotton goods. Following this came the incorporation in 1822 of the Amesbury Flannel Co. and after it the erection of the Horton factory or No. 2 mill. The rapid increase of the manufacture of woolen goods, crowded out all other minor branches of manufacture, and the old 'rolling mill' was converted into a woolen mill. For a few years past and up to the time of its removal it has been used as the machine shop of the factory company. This mill

In 1797, on December 29th, Perkins' first son was born and named Ebenezer. Of this eldest son very little has been recorded, though he lived until 1842. Of Perkins' second son, Angier March, born August 21, 1799, much more is known. He rose to eminence in his own field, as will be later shown. This second son was named for Perkins' brother-in-law and close friend, Angier March, who had married Perkins' sister Sarah. Angier March was by trade a printer and bookseller of Newburyport and in 1796 he owned the *Impartial Herald*, soon after to be styled *The Newburyport Herald and County Gazette*, in which enterprise he had for a partner William Barrett. This association, however, lasted but a few months and by the end of 1797 March was again sole proprietor until 1801 when he sold the newspaper to Allen and Stickney. Among his other enterprises, he founded the Essex Circulating Library in 1803, an act which greatly endeared him to the town.

Jacob Perkins' younger brother Abraham had been content to follow a more conventional and circumscribed and less romantic profession than Jacob. He carried on a general store in Newburyport "At the Sign of the Trumpet" at No. 4 Market Square. His advertisements in the *Herald* appear as early as 1795 [33] and as may be noticed, he offered to the citizens of Newburyport a most varied stock of merchandise. At that time he was selling, among many other things, his brother's machine-made nails, which found a regular and steady sale around the country and abroad, for undoubtedly many a keg found its way to the far-off West Indies in the natural course of trade.

VARIETY STORE

Abrm. Perkins,

Has for sale at his Variety Store near the Ferry way, a few elegant Britannia Tea and Coffee Pots—Common black tea do—Pewter of all kinds—Looking glasses—Bellows—Shovel and Tongs—Brass, Iron and Japanned Candlesticks—Post and Box Coffee Mills—Knives and Forks—Jack Knives and Pen Knives, various kinds—Copper Tea Kettles—Best Steel Plate Saws—Best and Common Hammers—Brass and Iron Chest and Box Locks—Hinges—20d, 6d, and 4d Nails—Fish Hooks of all Sizes—Tin by the Box—Iron coffee and tea spoons (tinned)—Pocket Compasses—Proof Glasses—A large assortment of Walking Canes and Riding Sticks—Tin ware of all Kinds—

West India Goods

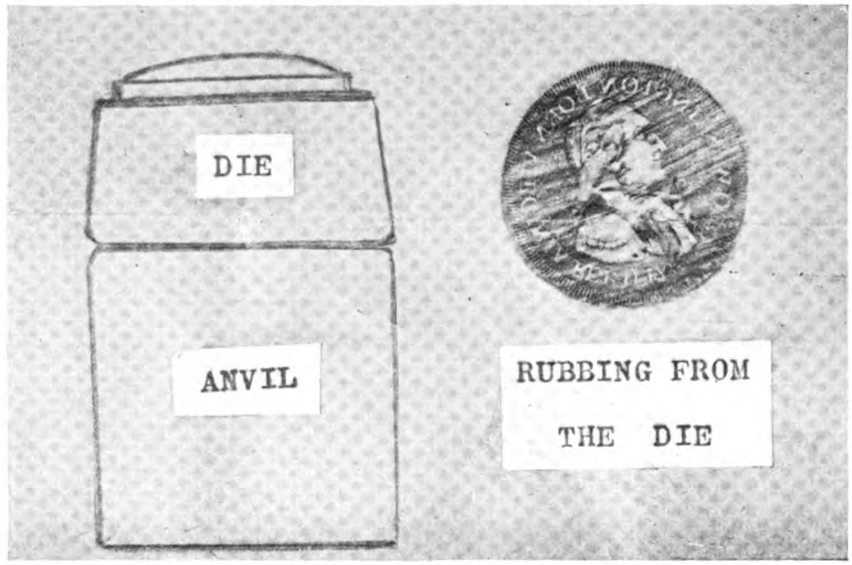
and a number of other articles cheap for cash.

Abraham Perkins' emporium was the equivalent of the modern hardware store, and in England he would have been called an ironmonger. He obtained most of his stock from the trading vessels which used the port. His Britannia ware came from Birmingham, his penknives from Sheffield though the jackknives he sold were a native product often called Barlow knives. These had wooden handles and were much beloved by New England men and boys for their eternal pastime of whittling. Much of Abraham's trade would have

was the 'advance guard' so to speak of manufacturing industry and skill in this village, and on its site is now being erected a fine six story brick building to be used as a finishing mill for the extensive works of the company. Seventy years ago manufacturing on the Powow consisted of a 'snuff mill,' 'oil mill,' 'rolling mill' and 'five saw mills.' Their places are now occupied by seven large factories filled with machinery in busy operation, giving employment to upwards of 1000 hands and it is estimated that the new mill when completed and in full operation will add 300 more to the working force, or a gain of 500 to the population of the village."

[33] *The Impartial Herald* was at this time owned by Angier March and Edmund M. Blunt. Blunt was an early publisher of nautical almanacs and later of the *American Coast Pilot.*

The Bicentenary Marker at Byfield where Jacob Perkins first developed his Nail Machine.



Steel Die made by Jacob Perkins for striking Washington's Mortuary Medal, 1799. *Reproduced by permission of* Miss Adelaide W. Currier, Newburyport.

Abraham Perkins,
At the sign of the Trumpet, *Market-square,*
HAS FOR SALE,

A GENeral assortment of HARD WARE, and W. INDIA GOODS, consisting of

London Pewter; Shovells and Tongs—Iron Ware.

A very large assortment of Knives and Forks—pocket and penn Knives—Shoe and Butchers do.—Joiners Tools—Box and Post Coffee Mills—Flat Irons—Bellows—Chaffindishes.

Looking Glasses; Brass and Iron Door Handles—Candlesticks—Teapots—Locks of all kinds—Prospect Glasses—Tin Ware—Wooden Ware—Flutes and Fifes—Violin Strings.

Scales and Weights; Hammers—Brushes—Wire, &c.

Perkins' patent cut Nails, & Brads, by Wholesale or Retail.

Tea, Coffee, Sugar, Molasses, Brandy, Rum, Gin, Rice, Flour.

Umbrellas of various sizes and qualities,

A great variety of other Articles, Cheap as at any other place in Town.

Perkins' Patent Nails for sale in the *Newburyport Herald*, November 10, 1797.

NAILS & BRADS,
Of Superior Quality.

NEWBURYPORT Patent Nails & Brads, are now ready for sale at the following prices by the Cask.

4d. NAILS	36 Cents pr M.	(wt. 3 lb.)	or 12 cts. pr lb.
6d.	72 do	do - - 6 lb.	or 12 do do.
8d.	88 do	do - - 8 lb.	or 11 do do.
10d.	1,20 do	do - - 12 lb	or 10 do do.
12d.	1,50 do	do - - 15 lb	or 10 do do.
20d.	1,80 do	do - - 20 lb.	or 10 do do.
2d BRADS,	25 Cents pr thousand.		
3d	30 do pr do.		
4d	35 do pr do.		
6d	2—3ds of a dollar pr do.		

8d, 10d, 12d, 20d } Same weights and prices as Nails.

Sheathing Nails, much superior to wrought, 10 Cents pr pound.

—By ABRAHAM PERKINS, Newburyport.
THOMAS M. CLARK, Do.
EBEN. PREBBLE. 68 Long Wharf, Boston.
MICHAEL WEBB, Salem.
GUPPY & ARMSTRONG, New-York.

Great care will be taken to make these Nails and Brads as perfect as possible—on a comparison it is presumed none either of American or Foreign manufacture will be found superior.

Contracts to deliver any quantity (either for exportation or home consumption) not exceeding one thousand Tons annually, will readily be entered into by the Patentees.

ARMSTRONG & PERKINS.
Newburyport, April 26, 1798.

Nail and Brad Prices given in the *Newburyport Herald*, May 8, 1798.

TO BE SOLD,
(If applied for in thirty days,)

The Nail Manufactory
At AMESBURY in the County of Essex,—*consisting of*

THE Mills, Water-Course, and Buildings with the land under and adjoining, and the Utensils and Machinery thereto belonging.

ALSO,

A very valuable Machine for cutting and heading Nails at one operation, with the Patent Right for the exclusive use thereof, which was originally granted to JACOB PERKINS.—The Premises being the same which lately belonged to JOHN WARREN ARMSTRONG, and which he conveyed to the subscriber.

The Mills are situate upon *Powow* River, near where it empties into the Merrimack, about five miles above Newburyport—The Premises are in excellent repair, and for the Capital necessary to be employed, may be rendered as productive as any Manufactory in the State.

For terms apply to Mr. ROBERT FOSTER residing at the Mills, or to the Subscriber at Salem.

SAMUEL PUTNAM.
Salem, 2d July, 1801.

The Nail Factory offered for sale in the *Newburyport Herald*, August 4, 1801.

been on the barter system. By the end of 1781 Continental paper money had ceased to circulate and had all been recalled. But the notes replacing it, issued by the private banks, were so poorly engraved that counterfeiting was rampant, causing great loss to storekeepers and other traders. The exigencies of business seem to have demanded that a false bill should be put back into circulation at the earliest opportunity to avoid the inevitable loss but respectable shopkeepers had to be careful not to carry this too far for fear of offending their customers.

In 1795 was founded the Newburyport Commandery of Knights Templars and soon after Abraham Perkins, Jacob Perkins and Benjamin Perkins, their half brother, became members of the order. It is recorded that they and others were associated in conferring degrees of the Red Cross and Knight Templar. The fact that Perkins was a Mason is an interesting and little known aspect of his life.

In 1799 Abraham Perkins was still carrying on his general merchandising business in Market Square and with but little variation in the goods he sold. But it is to be observed that the patent nails have now been dropped from his regular advertisements, due no doubt to the disrupted state of affairs at the Amesbury Nail Factory. That Jacob Perkins had now returned temporarily to his jewelry business is evidenced by an advertisement which appeared often in the *Newburyport Herald* during the spring and summer of 1799:

SILVER EAGLES

Elegant Silver Eagles for cockades, of a new pattern approved by the Secretary of War and now universally worn in Philadelphia, maybe had of Abraham Perkins, No. 4 Market Square, Newburyport.

This particular period represented the height of the war fever against France, which had blazed up in 1798 over the continual French interference with American ships and the seizure of their cargoes. For a time war seemed inevitable but happily by the end of 1799 a commission sent over to Paris had managed to adjust the difficulties with Napoleon who, as First Consul, had recently come into power.

Although Perkins was profitably engaged during these uncertain days of 1799 in supplying the demand for silver eagles to be worn in the hats of patriotic citizens, this work was but a pot boiler to tide over his financial embarrassments and enable him to carry on the more important work which now demanded his entire attention.

The check plate protector that Perkins had invented in 1792 and which had more or less remained dormant during the subsequent years, had at last been patented, March 19, 1799, and he now sought to introduce it to the public attention. In the *Herald* of this year, May 14th, appeared a notice that

JACOB PERKINS.

Having invented an effectual check for detecting counterfeit Bank Paper, which has received the sanction of several Banks, and the approbation of the undersigned eminent artists in Philadelphia, and having obtained a patent securing to him, and his assigns, the exclusive right of the invention, hereby offers to his fellow-citizens the privilege of using it upon terms to be agreed on between him and any person disposed to avail themselves of a guard against counterfeits.

The undersigned having examined Jacob Perkins' new invented method to detect Counterfeit Bank Paper, do approve of the plan; it being impossible to engrave or sink two plates perfectly alike with-

out the original die or hub, the counterfeiter would find it impossible to make an impression which would perfectly gage with the check from the original die

Robert Scot, Engraver & Die Sinker [34]
James Smither, Engraver
James Akin, Engraver.

The check plate, more generally known as the stereotype steel plate, was one of Perkins' most meritorious, useful and best known inventions. By this timely device, it is probable that banks and private individuals throughout the world have been saved the loss by fraud of untold millions. From earliest Colonial times, up to the period under consideration, the forgery of paper money, drafts and other bank paper was an easy matter to any man who was handy with graver or pen. The early Colonial banking houses printed their own currency; at first, from wood blocks and then from copper plates. Blazons, scrolls and red ink endorsements were used as a means of protection against copying, but counterfeiting was an easy task and banks were in constant and serious trouble by losses from this cause.

The principle of the Perkins stereotype plate was to employ a number of separate dies, each engraved with elaborate designs, letters and figures; these dies, to the number of sixty-four, were clamped together in a strong frame, thus forming one complete die or matrix which was in turn transferred by pressure to the plate used for printing the paper. The name of the bank, town or denomination could be added or removed at pleasure. At first the printing plates were made from copper, soft iron or steel but the deterioration of the transferred design, due to numerous printings, was considerable and the plate rapidly wore out. About 1804 Perkins, it is recorded, "discovered a process for hardening and softening steel at pleasure" which enabled him to transfer the design on the matrix to a soft steel or iron plate which was then hardened. This process of treating iron and steel by annealing to soften it, and then by cementation to harden the surface, has long been an accepted engineering procedure but to Perkins must be given the credit of successfully adapting this method to such flat and delicate surfaces as engraved plates.[35]

Perkins himself stated [36] that by 1805 sixteen banks were using his plates. Of these, the Newburyport Bank was one. This bank, the successor of the Merrimac Bank founded in 1795, was on March 8, 1803, reorganized by nine businessmen of Newburyport, among whom was John Greenleaf, a brother of Perkins' wife Hannah. An early specimen of Perkins' engraving on copper for this bank, prior to the introduction of steel plates, is shown at the top of Plate VI. Other banks were the Hartford Bank, in Connecticut, incorporated in May, 1792; the New Haven Bank, incorporated October, 1792, but which

---

[34] Robert Scot, stipple and line engraver, was born in Scotland. Some of his first work was engraving plates for the Continental paper money. On November 20, 1793, he was appointed Chief Engraver of the newly established United States Mint at Philadelphia, at a salary of $1200 per year. This post he held until his death November 1, 1823. James Smither, was a resident of Philadelphia since 1768 where he worked for Robert Bell the publisher for many years. He was a portrait engraver of some note. James Akin was born in South Carolina in 1773. Studied the art of engraving in England and came to Newburyport about 1804, at the solicitation of Perkins, to assist him in producing bank notes. He also engraved portraits in stipple and line and in 1805 engraved several of the maps and charts for Blunt's *American Coast Pilot*. Akin went in 1808 to live in Philadelphia, with an office at 22 Mulberry St. He died July 16, 1846.

[35] Perkins in a letter to the Society of Arts in 1819 describes in great detail this process of heat treating steel plates and his method of engraving and transfer for printing bank notes. Refer to Appendix F.

[36] Currier: *History of Newburyport.*

did not function until 1796; the New Hampshire Bank at Portsmouth, incorporated in 1792; the Union Bank, Boston, incorporated June 5, 1792; the Norwich Bank, in Connecticut, incorporated in 1796; the Gloucester Bank at Cape Ann, Massachusetts, instituted in 1796 and incorporated June 21, 1800; the Middletown Bank, in Connecticut, incorporated October, 1795, but which did not commence operations until July 20, 1801, and others.

The early historian, Williamson,[37] speaking of the Maine banks, says "the General Court in 1805 allowed banks to issue bills 1, 2, and 3 dollars equal to one-fifth part of their capital stock. Lastly, to prevent another and the greatest evil of all, namely, *counterfeiting*, the General Court, the same year sharpened the penalties against crime and afterwards required all banks to use Perkins' ingenious plate, which has never been successfully *counterfeited*." The Maine banks at this time were the Portland Bank, chartered July 15, 1799; the Maine Bank, chartered June 23, 1802; the Lincoln and Kennebec Bank at Wiscasset, chartered June 23, 1802; and the Saco Bank at Pepperelborough, chartered March 8, 1803.

At this time, 1805, Perkins stated that [38] "The standing part of these plates were elegantly engraved by Mr. James Akin, the work on the Master Steel plate or matrix occupied six or seven hundred days work, but when completed, impressions including the name of the bank and town it was consigned to, could be supplied easily by transferring[39] to another soft steel plate which was in turn rehardened." In other words, a combination of plates were used, one the temporary plate to print the face of the note as required by the banks, and another of most intricate design to print either front or back, which latter it was hoped could not be copied because of the extreme labor, time and skill which would have to be employed by a prospective counterfeiter.

The paper used for printing the bank notes was generally supplied by the banks themselves. This paper was of tough, thick quality, rather rough surfaced with the bank's water mark woven into the texture. A very careful check was kept upon every sheet of this paper to prevent theft, even spoiled sheets had to be accounted for. Before Perkins was permitted to print the notes for a bank, he was required to furnish a receipt, signed by a witness from the bank, for the number of sheets of paper which he took away with him. Such a receipt, given to the Essex Bank in Salem, Massachusetts, dated 1803, reads: [40]

> Received from the Directors of the Salem Bank twenty six quires & one sixth of a quire, making six hundred & twenty eight whole sheets, or twelve hundred & fifty six half sheets of Bank paper each bearing the water mark "SALEM BANK", which paper, after having made the impressions thereon agreably to the instructions which I have received, I promise to return immediately to the said Directors, & am accountable to them therefor

26 quires & 4 sheets
making 628 sheets
or 1256 half sheets

Jacob Perkins

Newburyport June 6th 1803
Witness:

John Moriarty.

[37] C. D. Williamson: *History of Maine*, 1832, Vol. II, p. 595.
[38] Currier: *History of Newburyport.*
[39] There is no mention here of the *transfer roller* used to receive the impression of the matrix which in its turn was used to roll the impression onto the printing plate. The principle of this transfer roller was essentially the same as the cylindrical roller seals of the Assyrians, used to produce impressions in a wholesale way. It is possible that Perkins did not use a roller at first for transferring to the printing plate (see Plate XIII) but used instead some kind of screw operated clamp to provide the required pressure.
[40] Perkins' Papers: The Essex Institute, Salem.

The cost for printing was for large bills 6 cents, and for small ones 4 cents. A receipt given by Perkins to the Salem Bank, dated July 1, 1805, shows that a stereotype plate for printing cost $70.

While the development of the stereotype process had been going forward between the years 1799 and 1805, Perkins had been actively engaged in other directions also. Among other matters which occupied his interest at this period was the improvement of the antiquated fire equipment of his native town. Up to at least 1768, the more important communities of the colonies purchased their fire engines from England, for these are often found in the lists of ordinary imported articles. However Ewbank states[41] "It is not impossible that some engines were made in Massachusetts about the time of the Revolutionary War." After the separation from the mother country, the manufacture of fire engines became more or less the product of individual and local mechanical talent. At best, these early engines were but two single acting pumps of small diameter, fixed in a wooden trough, mounted on trundle wheels. It took six or eight men working a long handled lever to provide the power and overcome the friction of the hemp packed pistons. On July 9, 1801, Perkins patented an improved form of pump which had the working barrel enclosed in the air vessel,[42] making a very compact arrangement that could no doubt have been used to good advantage as a fire fighting engine. Perkins endeavored to interest the city fathers of Newburyport in this idea but nothing came of it at the time. It was not until 1812 after the disastrous fire of the previous year, which had damaged so great a portion of the town, that the selectmen voted to purchase a Perkins fire engine, of which particulars will be given later.

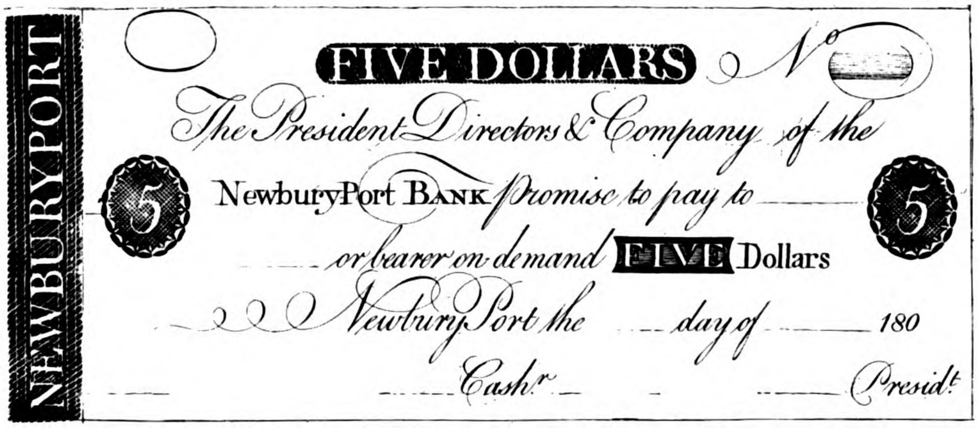
Perkins, at about the time of his pump patent, seemed to have interested himself briefly in well digging and in installing pumps for domestic purposes. He invented a screw auger of large diameter and with it bored test holes for prospective well sites.

Perkins' life in Newburyport was not all work and no play, as the following item, culled from the town records, will indicate:

"July 4th 1804—There was a military parade in the morning, followed by a dinner at Washington Hall on Green Street at noon and fire works, under the direction of Mr. Jacob Perkins, on the Mall in the evening." It is most probable that Perkins did more than merely direct these annual Fourth of July pyrotechnic displays, for how could his inventive instincts be denied in the manufacture of the fireworks themselves? The "Fruiloni wheels" with their two decks and centerpiece of colored lights, the "Maroon and Saucisson" bursting in a cloud of stars, the whirling fire of the "Tourbillons" and last but not least, the "Pots des brins" blasting their ways to the sky, and there spilling out luminous serpents, stars and

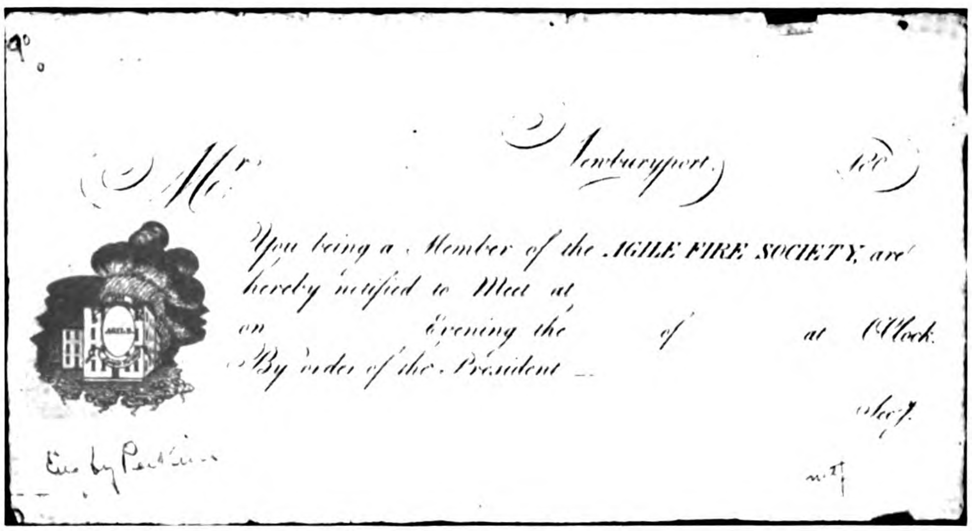
[41] *Hydraulic and Other Machines for Raising Water*, by Thomas Ewbank, 1851. Section "Fire-Engines in America," pp. 339-345.

[42] The air vessel of a pump is a separate chamber into which a part of the water is forced so that during the pause between each working stroke the compressed air continues the flow of water. This very necessary device is very old in application. The Egyptians employed this pneumatic principle in their primitive fire engines as early as 150 B.C. The air vessel was not revived until the end of the seventeenth century when two artisans of Amsterdam named Van der Heides again used this ancient idea in their fire engines. Perier in France, Leopold in Germany, and Richard Newsham of Cloth Fair in London incorporated the air vessel into all their fire engines and Newsham's engine of 1740, with two single acting pumps connected to a separate air vessel, became a standard for over 100 years. Perkins seems to have been the first to combine a single pump and air vessel which was equal if not superior in effect to the average fire engine of this period. That these pumps did not come into use readily was because of their more complex construction which involved machine work beyond the average skill of those days.



Example of copper plate engraving by Jacob Perkins. One of four notes of different denominations on the same plate. *Circa*, 1803. *Reproduced by courtesy of* Mr. F. Abbot Goodhue, New York, the owner of the plate.

Perkins' Signature in 1803.



Example of copper plate engraving by Jacob Perkins. *Circa*, 1806. *Reproduced by courtesy of the* American Antiquarian Society, Worcester.

noisy crackers; yes indeed, Perkins must have had his mind and hand bent to the making of these fiery delights many weeks before the night of the celebration.

By the year 1806, Perkins was beginning to reap some of the reward of his invention of the stereotype steel plate for engraving.[43] By now, he had ceased to be the goldsmith and jeweler and the manufacturer of odd trifles of adornment. The silver buckles had had their day, as had the gold beads. Perkins, now forty years of age, was the proprietor of a successful business. He engraved on both steel and copper and employed the best artisans of the day to assist him. He had acquired a fine three storied house at No. 14 Fruit Street where he and his wife Hannah enjoyed a comfort and security of living not hitherto possible. Perkins had by now six children, two sons and four daughters with another child expected within the year. He had lost one daughter, Jane, who died in 1801 at the early age of five. At the advanced age of 81, his father, Matthew Perkins, was still living and his mother, too, though she was to survive but another year. Her death took place on July 7, 1807. For Perkins these were kindly and prosperous years full of the social amities of a small but thriving New England town and the more weighty matters of its business world to occupy his energetic mind.

Perkins published very little during his long life, hardly anything more than half a dozen small pamphlets, comprising a few pages each. A complete list of these is given in Appendix J. One of the first of these written by Perkins was published January 1, 1806, principally for the convenience of bankers who were then using his patent plates, and also to impress merchants and storekeepers, the greatest sufferers through spurious notes, with the advantages to be gained by supporting his plan. The title page of this reads:

THE PERMANENT STEREOTYPE PLATE

With Observations on its Importance,
and an explanation of its Construction
and Uses, C. Stebbins—Printer, 1806
By
Jacob Perkins,
Newburyport

This little book, of which several copies are still in existence, measures seven and one-half inches long by four and one-half inches wide with marbled paper covers. It consists of six pages of printing describing in glowing terms the advantages of Perkins' stereotype system, and contains a folding plate with reproductions of three $5 and one $10 bills. Another book of more importance published at this time at the instigation of Perkins was entitled *The Only Sure Guide to Bank Bills; Or Banks of New England With a Statement of Bills Counterfeited*. This was published by Gilbert and Dean and priced at 12½ cents. This book contains a list of all the counterfeit bank notes known to be then in circulation. It is a comprehensive and significant document and most clearly indicates the necessity at

[43] Stereotyping is a process for making solid plates from type or separate designs so that the printed sheet can be reproduced indefinitely without variation. The first stereotype plates were made from plaster about 1731 in Scotland and were used for printing Bibles and prayer books. Lead stereotype plates were successfully used in France about 1793. Stereotyping was introduced for book printing in America, by David Bruce of New York in 1813. The advantage of using hardened steel plates was their long life without appreciable wear, particularly for printing bank notes and illustrations for fine editions. Perkins was the first to use steel plates in the stereotyping process although his steel plates were used for a variety of other artistic purposes.

that time for a more certain method of preventing forgeries. If denied the opportunity of crime in one direction, a rogue may often turn to something equally evil but it will be conceded that although Perkins made his forgery-proof plate and bankers used it for their own profit, yet indirectly many a man must have been saved from his own inherent weakness by the difficulty which confronted him after the banks began to use the stereotype system.

To obtain a wider and more permanent field for his stereotype plates, Perkins hoped to interest the Commonwealth of Massachusetts to the extent of passing a law enforcing the use of his plates by all banks in the state. Although the First Federal Bank of the United States was functioning, it did not have the power to impose banking laws upon individual states and even within the states bankers conducted their various businesses more or less along their own individual lines.

The solicitation by Perkins to the General Court of Massachusetts in 1806 seemed a propitious beginning for the carrying out of his plans along these general lines, particularly as there were many prominent bankers and businessmen who, having suffered through the prevalence of forgery in the past, were vitally interested in having introduced some uniform system of printing bank bills. Chief among these men was Israel Thorndike,[44] an influential banker of Salem and a stanch believer in Perkins' invention. Also there was Jeremiah Nelson,[45] a Newburyport merchant and an intimate friend of Perkins who had already paved the way for a Bank Bill during the years he had served as representative to the General Court of the Commonwealth.

Perkins' petition, dated February 28, 1806, reads: [46]

The Memorial of Jacob Perkins of Newburyport in the County of Essex, gentleman, respectfully sheweth:—

That your memorialist has invented and made a Stereotype Plate of steel for impressing Bank Bills, by a new method and upon a new principle. He formerly invented a method of impressing bank bills upon the like principle with distinct copper plates, for each different Bank for which he obtained a Patent under the seal of the United States. He has since improved that method by making the said steel plates, which can be fixed with separate dies, also made of steel for all the different denominations of bills and suited to the different stiles of banks; so that all the bills impressed with his plate, for what ever bank, will in all the material parts, check and perfectly compare with each other. He has also secured to himself and his assigns the exclusive right of using this improvement, according to the laws of the United States—

Your Memorialist has expended at least eight hundred days work of himself and his workmen, in making and perfecting his said steel plate, and was proceeding to avail himself of the fruits of his labor, by contracting with the different banks for the use thereof, when he was flattered to hear that the Legislature of the Commonwealth had, unsolicited by him taken the subject into their wise con-

[44] Israel Thorndike, born 1757 in Beverly, formerly a part of Salem, Massachusetts. In the Revolutionary War on October 30, 1776, he was appointed captain of the privateer *Warren*. After the peace he became a banker and engaged extensively in the China trade and in the West Indies, which proved very successful. In 1810 he settled in Boston as a merchant banker and there remained until his death on May 10, 1832.

[45] Jeremiah Nelson, of Newburyport, born September 18, 1768. Advertisements in the *Impartial Herald* during 1794 indicate that he was a soft goods merchant. In 1803 and 1804 he was elected representative to the State Legislature of Massachusetts. In December, 1805, he took his seat in the Ninth United States Congress then in session in Washington, his term expiring May 3, 1807. He was again elected in 1815 and re-elected several times afterward, until his retirement in 1825.

[46] Addressed "To the Honourable the Senate and House of Representatives of the Commonwealth of Massachusetts in General Court assembled." The petition is handwritten on three sheets, 15 by 9½ inches, in the possession of the Antiquarian Society, Worcester.

sideration, and were contemplating to introduce this improvement into general use. He has understood the mode proposed for this purpose, by the bill now pending in the Honorable Court, and is willing to deliver up his said steel plate, with the necessary dies, on or before the first day of July next, to the Treasurer of the Commonwealth for the purposes expressed in said bill—

This plate was intended and is equally well calculated for banks of other states, with the alteration only of a small part of the margin but your memorialist understanding that it is desired to have the bills of all banks in this state to differ in kind shape and appearance from those of other states, will also agree, in case the said bill passes into a law, not to use said plate for any Banks out of this state; but to make a new plate for those banks, which shall differ in its form and appearance from that now made, so that the bills of any Banks in this state can be readily and certainly distinguished from those of all others—

This plate is made of casehardened steel; so that it can be used as much as may be necessary for fifty years, without any sensible change or deterioration. Your memorialist is also willing in case such a law should be made, to print and impress all the bills required to be made in virtue thereof as fast as they can be properly executed on the reasonable demand of the banks in this state. He will perform all the above services on terms similar to those for which he has hithertofore agreed with sundry Banks, with the addition of a reasonable compensation for his said plate, which will by these means be rendered useless to him for all other Banks. His terms are as follows; 1st He shall receive from each bank in full for printing and impressing their bills, at the rate of four dollars, for every hundred impressions or half sheets to be paid when the bills are delivered. 2ly He shall receive from each bank at the same time, the sum of forty dollars in full for his said plate to indemnify him for the expense and labor of making a new plate, which cannot be less than one thousand dollars. 3ly In addition to the above compensation for his labor and expense, he shall receive for the use of his patent right, by every bank whose capital stock actually paid in does not exceed one hundred thousand dollars, the sum of fifty dollars annually; by every bank whose capital stock so paid in is above one hundred thousand dollars and not exceeding the sum of two hundred thousand dollars, the sum of seventy dollars annually; and by every bank whose capital stock so paid in exceeds two hundred thousand dollars, the sum of ninety dollars annually—These annual payments to commence ——— ——— ————— and the first payment to be made by each Bank, in one year from the time when he begins to impress their respective bills, and to be continued by each bank until they respectively cease to use the bills impressed by his said plate, or until all his assigns cease to have the exclusive right of using his said improvement. And if the propriators of any bank after their bills are so impressed by him, shall pay in more of their capital stock, so as to make the amount gain into a higher class, according to the above distribution, such bank shall immediately thereafter pay the annual sum above given for such higher class. These annual payments to be properly and satisfactorily secured to the said Perkins, his executors, administrators and assigns, by each bank at the time of receiving their respective impressions—

Your memorialist presumes, that the paper, which is directed by the said bill to be furnished by the Treasurer will be provided at the expense of the Commonwealth, the cost to be repaid by the several banks as they respectively call for the same. But if this should be thought improper or inexpedient, your memorialist is willing to advance the price thereof if it should be necessary, according to the contracts thereof made by the Treasurer, the cost to be repaid to him by each Bank as they respectively call for and use the same.

Perkins' petition received general approbation, but after the manner of legislative bodies, it was not immediately acted upon. However, it did bear fruit later when the Massachusetts Banking Act of 1809 was passed and Perkins' stereotype plates were exclusively adopted in the Commonwealth. From an article in the *Boston Repository*, written by Perkins and dated February 4, 1806, it is interesting to note his terms to bankers which were on a royalty basis, plus an extra charge for their personal requirements. Plates of copper used for the lower denominations were still in vogue, but after the passing of the Massachusetts Banking Act, steel plates seem to have been used exclusively. Quoting from his article in the *Repository*, Perkins said:

Banks that adopt this principle of making bills are furnished each with eight steel dies, containing the name of the bank and town; which are kept by the bank for its own security. At the rate of $4.00 for every eight impressions, is charged for printing; and as there is no charge for plates and dies, the expense will not be greater than the usual mode. For the patent right, banks pay from Thirty or One Hundred Dollars annually; should their bills be counterfeited, no pay is required. Bills of less denomination than Five Dollars are printed from copper Stereotype which is an infallible check against altering them to any of a higher denomination.

Jacob Perkins.

Newburyport, Jan. 1 1806.

During this year 1806, there came before the Committee of Commerce and Manufacture the petition of George Dodge and others, now joint owners of the Amesbury Nail Factory, for a renewal of the Perkins patent for a further seven or fourteen years. (See Appendix C.) The reason for this request for an extension of the patent at this time was that the Amesbury Nail Factory had been totally destroyed by fire the previous year. It is recorded that [47] "a fire was discovered at 4 a.m. on Dec. 24th on the premises of the nail factory, which burned that building, a grist mill, two blacksmith's shops and three hundred cords of wood. It was described as the greatest conflagration then known. The damage was estimated at $80,000, which in those times was a very large sum."

The petition of the proprietors of the nail mill was refused and as far as is known, Dodge and his associates withdrew from the nail business. The mill, however, was rebuilt later and was operated by other owners as an iron works until it again suffered by fire in 1811.

Though Perkins no longer was particularly interested in the fate of the destroyed nail mill, he still must have had some rather bitter memories of its earlier days and his work there, the controversies with his partners and final loss of his patents.

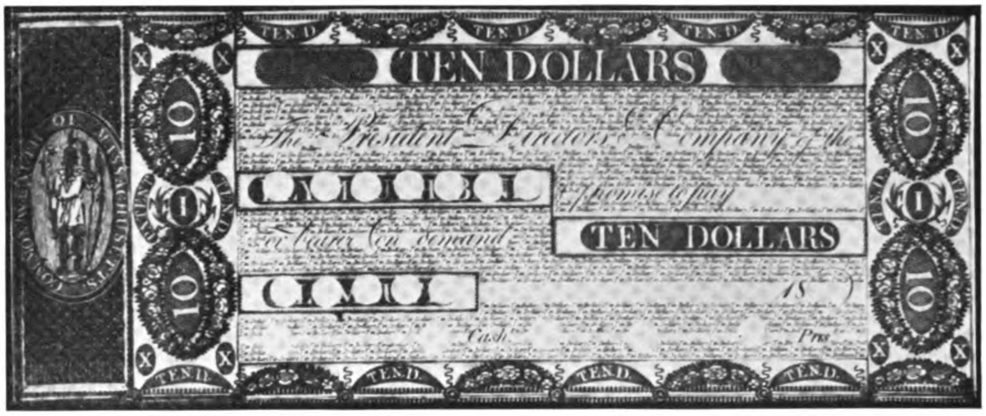
Although for many years much legal controversy raged around the users of Perkins' nail machine and patentees and assignees of new machines, it seems that Perkins himself was never involved directly, even as a witness, in any of these cases. Perkins did, however, in 1813 petition Congress to renew his patent of 1799 but this was refused as it had never been extended at the time of the Dodge petition. But of this more later.

The engraving and making of plates for various banks, together with the printing of their bills, engaged Perkins' attention for the next few years. In addition to this, he engraved on copper, promissory note forms for private bankers, book plates for printers and decorative notice cards for societies and lodges.

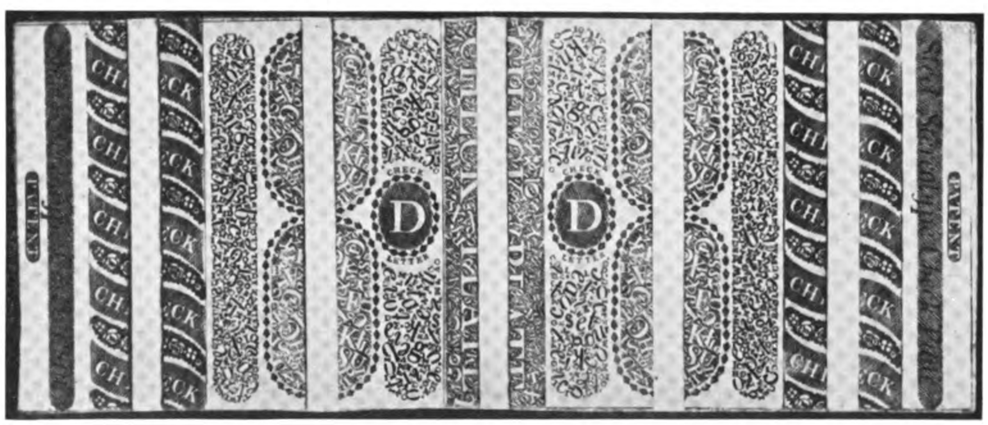
On March 4, 1809, the Commonwealth of Massachusetts passed a special Act (Appendix D.), effective on July 1st to enforce the printing of all paper money in the state by Perkins' stereotype steel plates and also to promote more uniformity in the design of bank bills. The passing of this Act was no doubt a great triumph for Perkins, not only as a vindication of his skill and ability but also from the point of view of its financial advantages.

It was by then generally conceded by many of the banking houses of Massachusetts, as well as those in other states, that the Perkins system of steel plate engraving had fully justified the inventor's claims. Few instances of attempted forgery of these had been recorded by banks using the plates while other banks which still clung to the older methods of copper plate printing were becoming more and more often victimized by counterfeiting.

[47] *History of Amesbury* by Joseph Merrill, 1880.



Example of steel plate engraving for the State Banks of Massachusetts, 1809. Specimen Bank Note for Ten Dollars.



Back of a note showing Perkins' Patent Check Plate. *Reproduced by courtesy of the* American Antiquarian Society.

The Check Plate for Back Printing

That the stereotype system was not considered absolutely infallible may be gathered from Governor James Sullivan's speech to the Legislature, March 4, 1809. He said:[48] "Though this ingenious invention did not have the full effect anticipated, yet it has been useful and has continued to retain its hold upon public estimation. Its durability has far out run that of many devices for a like purpose." If in 1809, the Legislature of Massachusetts was not entirely satisfied as to the invulnerability of the steel plate which it was about to adopt by law, with the passing of time its value to the state was acknowledged in no uncertain terms, for on February 20, 1824, the following statement was made in the State Legislature [49] "Having witnessed that the notes of banks, struck from Perkins' stereotype plates were seldom successfully imitated, the Legislature again recommends them to be used by all corporations in their jurisdiction."

By the time Massachusetts adopted the stereotype system, Perkins had further improved the check plate to secure greater safety as well as to simplify the detection of counterfeit currency. The construction of the new check plate used for the back printing on bills is shown on Plate VII and as will be observed, the surface is divided by five blank strips. The engraved portion of the check plate was composed of six steel bars, which, when the surface of these was impressed by the matrix, were clamped together in a frame; afterward they were casehardened and then separated by five narrow strips of steel which divided the letters and other engraved work as chance directed.

In 1809 Perkins issued a seven-page brochure describing this improved check plate, with samples included of the Massachusetts paper currency. This pamphlet was entitled *Perkins' Bank Bill Test* and was published by W. and J. Gilman, printers of Newburyport. Perkins' directions for gauging and comparing suspected bank bills taken from this publication, reads: [50]

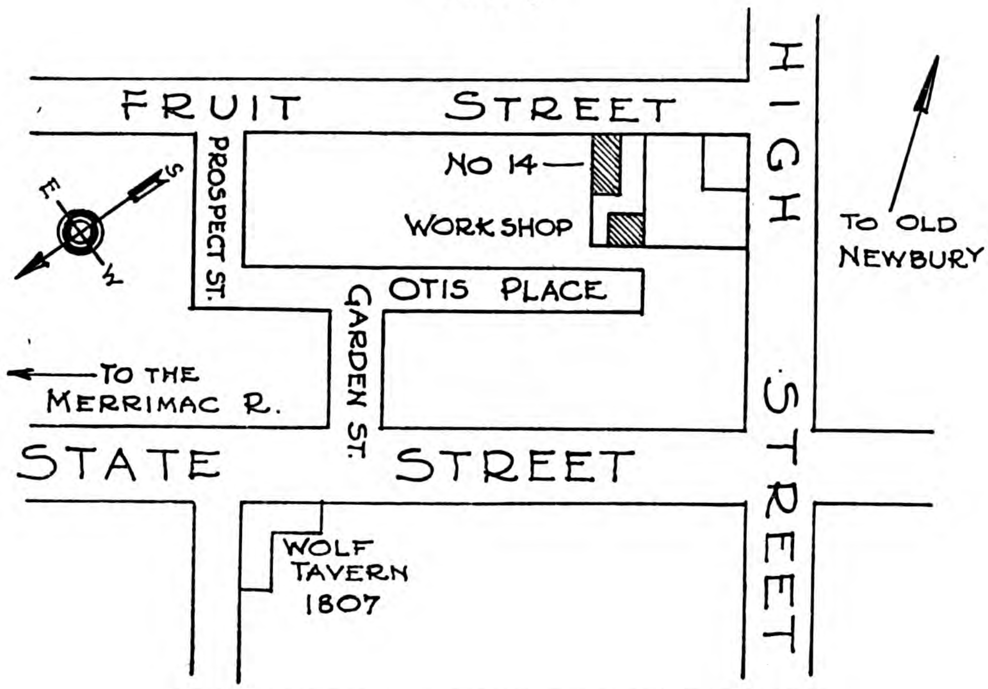
> All Bills of Five Dollars and upward, made upon the foregoing plan, will be impressed on the back with the check plate. Every genuine Bill will gauge with one or other of the four backs on the plate according to the check letter, A.B.C. or D.
>
> In gauging particular care should be taken to fold the suspected Bill exactly at one of the lines of separation, and to match it with the opposite line on the check plate.
>
> If the Bill be rumpled by much handling or contracted, in consequence of having been wet, and then suddenly and carelessly dried, it should be gently stretched, until the extreme or outside parts of the work exactly coincide; then, if all the intermediate letters and other work perfectly match or gauge, the Bill must be genuine.
>
> Another mode of discriminating between the genuine Bill and the counterfeit, is by a general comparison of the Bill itself. This may be done by laying the suspected Bill under the genuine Bill having the same check letter; then carefully examine whether the letters and other work are precisely the same in each Bill. If the suspected Bill be spurious there will be an obvious difference in the form, general appearance, or relative position of the letters and the other work, which will generally leave no doubt as to the character of the Bill.
>
> This latter mode will usually be found the more easy, and it is presumed will be sufficiently accurate and effectual. It will be found particularly, the preferable mode of testing Bills under Five Dollars, such Bills having no check impression on their back.

It will be observed from the foregoing, that only bills of five dollars and over are mentioned as bearing the imprint of the check plate. According to the Massachusetts Act of

[48] Felt: *Historical Account of Massachusetts Currency*.
[49] Resolves of Massachusetts—From *Historical Account of Massachusetts Currency*.
[50] From a copy in the possession of the American Antiquarian Society, Worcester.

1809, bills of all denominations had to be printed by Perkins' patent plates, but the check plate for back printing was exempt from bills below the value of five dollars. The reason for this is not clear, probably it was considered unlikely that a counterfeiter would trouble to work over a forgery for sums as small as two or three dollars. The banks themselves could use the check plate on their bills below five dollars if they considered the extra expense worth the added protection but they were not required by law to do so. Banks were, however, compelled to deposit with the Commonwealth an original or sample impression of all the paper money they issued.

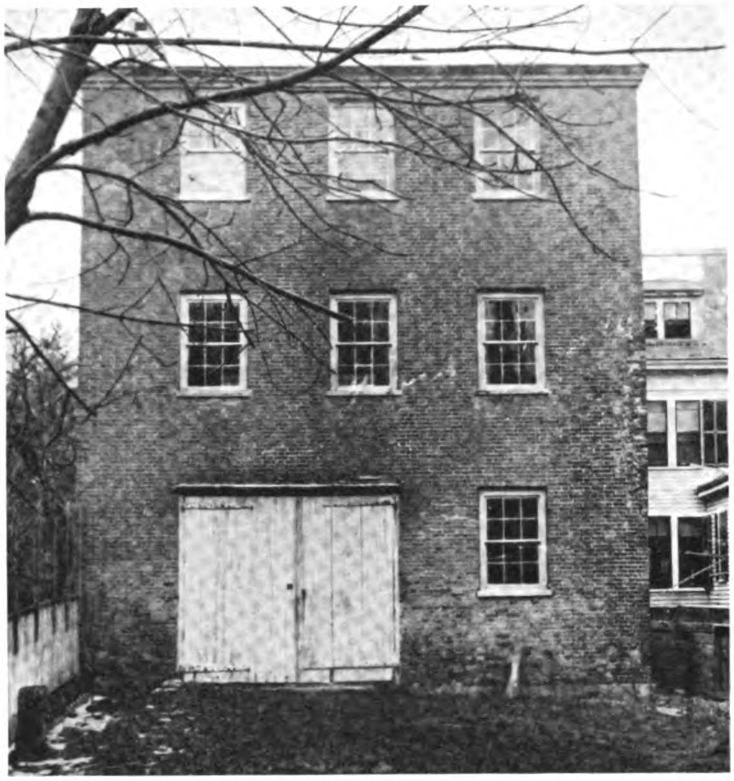
MAP 3



Map of part of Newburyport showing location of Jacob Perkins' Home and Engraving Plant. *Drawing by the authors.*

It would seem by this special Act that an airtight monopoly for bank note plates had been granted to Perkins and this should have greatly enriched him but for various reasons his expenses seem always to have outrun his profits and his finances were always greatly involved.

Early in 1808 Perkins had induced his brother Abraham to join him in his engraving and printing business and in July of that year, Perkins gave his brother a mortgage on his house, No. 14 Fruit Street, and for this security money was put into the business by Abraham, part of which was used to build a three-story brick building at the end of the garden of the Fruit Street place. (See Map 3.) Fruit Street was so named because in 1801, it had been cut through a large fruit orchard. The stipulation of the owner at the time of the transfer to the city was that only three-story houses should be built on the new street. It was for this reason that when Jacob and Abraham Perkins built their engraving plant, the



Jacob Perkins' Engraving Plant on Fruit Street, Newburyport,
Some Fifty Years Ago. *Photograph by* Noyes Studios.

The Perkins Engraving Plant and Home on Fruit Street as it is today. Now occupied by Mr. Frank Rollins. *Photographs by the authors.*

building had to have three floors. See Plate VIII. It was here on Fruit Street that the Massachusetts currency was engraved and most of it was printed.

The engraving plant now being in full operation under the careful supervision of his brother Abraham, Jacob Perkins turned his nimble mind to other inventive interests, one of which perfected at this time was a machine for polishing and graining morocco leather. A patent for this was obtained by Perkins on June 26, 1809. Morocco leather was very popular in early days for making pocket books, thread cases, purses, razor cases, dressing and traveling bags, instrument cases and for binding books. The *Newburyport Herald* repeatedly carried advertisements of local merchants offering these articles for sale. The cost of imported leather was very considerable and substitutes, principally of sheepskin, were often used especially for book bindings, shoes and coverings for desks and furniture. Genuine morocco leather, made from goatskins, is polished and grained entirely by hand, but machinery can be used for this purpose with success.[51] The details of construction of the machine invented by Perkins for finishing skins in the morocco style are not known. The patent gives his address as Boston and this work was connected with the Hampshire Leather Manufacturing Company, which had been incorporated that year by a group of Boston merchants. The works were very extensive and had a capacity for dressing 16,000 hides. The whole of the work was performed by machinery as far as possible, driven by water power. It is most probable that this invention was sold outright to the company by Perkins, as he could have made but little use of it himself.

Several other inventions were developed by Perkins while he was a resident of Boston. On June 16, 1810, he received a patent for improvements to copper plate printing which patent included a method for preventing counterfeits, and this also covered his recent improvements to the check plate. A month later, on July 17th to be exact, he was issued a patent for manufacturing cut nails and brads, which also included a device for forming their points.

In 1810 Perkins and the engraver Gideon Fairman[52] jointly published a series of copy books for teaching penmanship. These exercise books, which consist of spencerian letters, ciphers and brief sentences, are quite small, comprising eight pages, three inches wide by seven and one-half inches long, printed from steel plates. They are notable as having been the first books printed in this country by such method. The books were published under the title of *Perkins' and Fairman's Running Hand*, and were printed by Thomas

---

[51] For leather, finished by hand labor alone, the workman employed a polygonal ball of glass to polish the skins, while for graining or ribbing, a ball of lignum vitae scored all over by ridges, is used. By shifting the skin on the table, it is thus indented by crossing lines. Machines for this purpose have to be very sensitive, to accommodate the rollers to the varying thickness of the skins, as unequal pressure is liable to tear the skins as well as to produce a surface of varied and mottled finish. Luke Hebert (*Mechanic's Encyclopedia*, London 1836) gives the year—1811—when the first machine was built in England for polishing leather. This was subsequently improved upon by Joseph Ellis who combined in one machine both polishing and graining. Perkins' patent therefore seems to have been one of the earliest attempts to imitate hand-finished leather by means of machinery.

[52] Gideon Fairman was born June 26, 1774, at Newtown, Fairfield County, Connecticut. In his youth he was apprenticed to Isaac Crane, a blacksmith of New Milford. Ambitious to become an engraver, he went to Albany in 1792 and apprenticed himself to Isaac and George Hutton, jewelers and engravers. After he had served his time, in 1796 Fairman commenced business for himself and married in 1798. On January 8, 1802, Fairman and Isaac Hutton patented an "improvement in the art of engraving," of which there are no details. Fairman came to Newburyport to work with William Hooker about 1803. It is probable that he also engraved for Perkins at about this time.

& Whipple at Newburyport. They are now almost a complete rarity.[53] Gideon Fairman, Perkins' associate in this publication, was later to be his partner in Philadelphia and later still in London, but at this time Fairman was a junior partner of William Hooker, who engraved maps and charts in Newburyport. They had in 1808 jointly published a similar series of schoolbooks in both English and German text but made from copper plates by the old method.

Gideon Fairman first came to Newburyport about 1803 to assist Hooker in engraving a set of maps and charts of the principal towns and ports of the Atlantic coast from Cape Sable to the Florida Keys. These charts were later sold, with the addition of sailing directions, in volume form as the *American Coast Pilot,* which was published by Edmund M. Blunt, a bookseller on State Street, who also sold nautical instruments. Fairman, having had a business disagreement with Hooker, severed his connection with him in 1810 and came to Philadelphia at the suggestion of Perkins, to promote the introduction of steel plate engraving in that city. Very shortly after his arrival in Philadelphia, Fairman bought a partnership in the established book plate engraving firm of Murray and Draper. Though separated, friendly ties between Perkins and Fairman continued and no doubt it was Fairman's favorable reports of business conditions in Philadelphia which finally induced Perkins to leave New England for a newer and wider field of activity.

At this period, Perkins spent a good deal of his time in traveling between Newburyport and Boston, in order to keep in touch with his multitudinous interests in both places. One of the problems which confronted the engraving business in Newburyport was the responsibility for the safekeeping of the steel plates belonging to the various State banks. Perkins, writing from Boston under the date of February 19, 1810, addressed the following memorial to the State Legislature: [54]

To the Hon'ble the Senate and House of Representatives in General Court Assembled—

The Memorial of Jacob Perkins of Newbury Port in the County of Essex, respectfully shows—

That by the provisions of the act passed by the Legislature of the last year "requiring the several Banks in this Commonwealth to adopt the *Stereotype Steel Plate*" it is among other things required, that the plates mentioned in said act, shall be kept in the possession of your memorialist; that he considers the responsibility of thus keeping the said plates as too great for him; and he therefore prays, that the said plates may be taken out of his possession, and deposited in the keeping of such officer or officiers of the Government as the Legislature may think proper; or in the keeping of an agent for that purpose to be appointed; or that your Honors would take any other means upon this subject that may be found to comport with the interests and safety of the public—and as in duty bound will ever pray—

Jacob Perkins

Boston Feb.y 19th 1810.

A notation on the back of this letter shows that it was referred by the House of Representatives to a committee consisting of Mr. Apthorpe, Mr. M. P. Howard and Mr. Chesary. Later in the year, Perkins again memorialized the Commonwealth, this time on the subject of using a better grade of paper for printing the bank currency: [55]

---

[53] The only specimen of the *Running Hand* known to the authors is in the Taylor collection, of the American Antiquarian Society in Worcester.

[54] Massachusetts State Archives.

[55] Massachusetts State Archives.

To the Honorable Senate and House of Representatives of this Commonwealth of Mass. in the General Courts assembled.

I, Jacob Perkins of Newburyport in the county of Essex, beg leave to represent as follows;

Upon the enactment of a law by this Honorable body entitled "an act requiring the several incorporated Banks in the Commonwealth to adopt the Stereotype Steel Plate, in certain cases, & for other purposes" dated March 4th 1809. I gave a bond to the Commonwealth that I should use paper according to the samples deposited in the office of the Secy of the Commonwealth. Since that time improvements have been made in the manufacture of Bank paper, and several Banks have complained that the paper by law required to be used was not sufficiently good; altho I supposed it to be the best I could then have procured.

I therefore beg leave to make use for the Banks which may wish it: of the best paper I can get charging to the Banks the cost of that paper. But if any of the Banks should prefer the paper as deposited in the office of the Secy of State, I ask liberty to use it upon the condition expressed in my bond.

As in duty bound will ever pray
Jacob Perkins.

In 1810 the number of paper mills in Massachusetts was thirty-eight, which number was only exceeded by Pennsylvania which had sixty. Very little else was produced in these mills except rag paper and the consumption of rags for this purpose was enormous, as it required a pound and a half of rags to produce each pound of paper. Most of the rags used were imported at this time from Europe but only the finest quality material could be used for bank note paper. The engraved surface of the steel plates was of such incredibly fineness of detail that it was impossible to use the coarser, rougher paper of early copper plate days.

This petition of Perkins' was again referred to a committee of three, this time composed of Mr. Phillips of Boston, Mr. Devers of Cambridge and Mr. Win of Salem. These gentlemen reported favorably on the matter and were given leave to bring in a bill on February 8, 1811.

It would seem as if Perkins' anxiety over the safety of the bank plates was almost a premonition of the disaster which befell Newburyport on the night of May 31, 1811. A fire started in a small warehouse by the river and rapidly spread back into the town. The fire fighting resources were completely inadequate, as might well be expected, and before the end of the following day two hundred and fifty houses and shops lay in ashes. The loss was estimated at a million dollars, for the property destroyed represented the very heart of the community. After Newburyport had been partially rebuilt, it was decided to divide the town into six districts, each with its own volunteer fire company and the selectmen were also to provide a fire engine under these plans, this to be equipped with both long and short ladders, fire hooks, fire cloths, ropes and chains.

The recent calamity and the possibility of its reoccurrence at any time to the town of Newburyport had made a deep impression and the apathy of 1803 had now given way to a keen interest in acquiring a serviceable fire engine. A general meeting of the inhabitants was called on May 9, 1812, to decide[56] "whether they will purchase for use of the town a Hose Engine which will be exhibited near the Court House at the time of the Meeting." And after a brief discussion, the selectmen were instructed to "purchase Mr. Jacob Perkins' Hose Engine." In 1809 or thereabouts, Perkins had transferred his active business interests to Boston as offering a greater field for his siderographic printing. One of his business

[56] Currier: *History of Newburyport.*

acquaintances there was Allan D. Pollock, a manufacturer and importer of muslins who then lived at No. 1 Carver Street. There is little doubt that Perkins' connection with Pollock had originated through the possibilities of printing his muslins and other cotton fabrics by means of copper plates engraved by the Perkins system. Pollock had scientific tastes as well as manufacturing abilities and was an active member of the Society of Natural Philosophy in Boston. He was also the patentee of a heating stove (in 1808) and later in 1815 of a new kind of scale beam for weighing bolts of material in his own warehouse which was then located on the south side of Boston Market. Pollock in 1817 became Sealer of Weights and Measures for Boston, a position he seems to have been well qualified to hold.

It is little wonder after the Newburyport fire in 1811 that Perkins was filled with a desire to revive the possibilities of his patent pump of 1803 in its most suitable application which was in a fire engine, and he sufficiently interested Pollock into becoming his partner in the venture of constructing a trial machine and taking it up to Newburyport. The engine was built in Boston, probably by the brothers Thomas and Nathanial Frothingham, coachmakers with premises on West Street, near Boston Common. When finished it was taken up to Newburyport, arriving May 5, 1812. After the satisfactory sale to the town, much further business was anticipated from other quarters and Perkins and Pollock patented the fire engine on August 6, 1812. An announcement in the *Newburyport Herald* of February 1, 1813 stated: "that a new style of fire engine had been patented by Mr. Perkins of Newburyport and Allan Pollock of Boston." Probably after this a few more of these patent fire engines were built but of this there is no definite record. The Newburyport engine, which was the pride of the town for many years, was housed in 1815 in Market Square and later in 1821 it was removed to Middle Street. From then on, its fate is shrouded in obscurity.

Soon after the beginning of the year 1812 the gloomy prospects of a second war with Great Britain were fulfilled and after the declaration of war by Congress on June 19, 1812, hostilities commenced upon the Canadian border near Detroit. Though the land fighting never touched Newburyport, the little town had its share of trouble from the sea. Perkins' son, Angier March Perkins, many years after in London with his memory mellowed by his seventy-odd years, wrote in his personal notebook some of the events of his long and active life and among his other memories, he tells a little of these stirring times of his boyhood:

> I was born in Old Town, where my mother had retired in consequence of yellow fever, about two miles from their residence at my uncle March's, Mr. Angier March for whom I was named. The fever was very bad and my grandfather Greenleaf and my grandmother Greenleaf died of it, near about the same time. They were my mother's father and mother. I have no distinct recollection of the events for the seventeen years of my life. There are however a few circumstances which did occur of which I have a recollection—which I will endeavor to relate. At the age of 12 years there was an embargo laid upon the ships of the harbor by the Government and I went down on a wharf to see it. There was a small vessel ashore and I was told that this was it, I was ignorant and believed for some time that was it. It was wartime between Great Britain and the United States of America—at this time there was a British Man of War on the coast, and we were called out to go toward Plum Island to build a battery, and I helped a little, There was a large comet in the sky in 1811 which was considered an omen of the war. There was a total eclipse of the sun which I recollect very well. About this time I fell in love with Sarah Bodily which lasted till I left the town for Philadelphia. She after-

ward married Ebenezer Wheelwright and I have just heard of her death. She was a month younger than myself.

Later on in his youthful reminiscences Angier March continues:

During my residence in Newburyport I used to go with my father occasionally "a-gunning", which he used to be very expert in, but very seldom allowed me to take a gun, except with him. I have a recollection of being allowed one occasionally. I recollect of being once at a place called Black Rock on the seaside, and while he was making a fish soup called chowder, I took up his gun and fired at a gull flying over head and killed it. He was surprised and called me a rogue saying "You rogue, you have shot him", I was delighted when he called me a rogue as he was pleased when he called me so. There were several occasions which I could name of the like kind. I remember my uncle March on his death bed and I was taken in to shew myself in a coat which was made for me out of his marriage coat, and this is all I can remember of it.

So reads Angier March Perkins' delightful recollections of his early life in old Newburyport.

Of the many people whom Perkins was associated with during a long business career, perhaps the most outstanding character of all was Joseph Chessborough Dyer.[57] He was a man of cultural background and education, a pioneer in new enterprises and a promoter of useful inventions. Dyer was also a New England man and had made his first visit to London in 1802 to study the industrial conditions of the country and broaden his knowledge of manufacturing methods. He was a rich man both by inheritance and through his own business abilities. To these advantages, he added a decided partiality for all things mechanical which led him to seek out inventions along lines which could be profitably developed to his own and the public's advantage. Of his day he was the prototype of our modern business promoter. Between the time of his first voyage in 1802 and 1811 when Dyer settled permanently in England, he made many trips between Boston and London in connection with his business enterprises in both cities. Dyer seems to have first become acquainted with Perkins in Boston about 1809, at the period when Perkins was working on his third nail machine invention. He was undoubtedly greatly impressed with the improved Perkins machine which cut and headed nails so rapidly with only one movement of the power lever. The possibilities of such a machine in England seemed to Dyer unlimited, for automatic repetition devices for making nails, brads and tacks at this time were one of the most undeveloped branches of manufacturing. In spite of the tremendous export of British nails from the Midlands, and especially Coventry, which amounted to over two thousand tons annually, the greater bulk of these were still made by hand on small home forges.

Just what kind of business agreement was made between Perkins and Dyer is not known but Dyer patented the Perkins nail machine in his own name in England on July 26,

[57] Joseph Chessborough Dyer, born at Stonington Point, Connecticut, on November 15, 1780. He was the son of Captain Nathaniel Dyer. In 1811 Dyer endeavored to introduce Robert Fulton's steamboat to the British nation but without success. After he settled in Manchester, England, in 1814 he came into public prominence as one of the founders of the *Manchester Guardian* in 1821. He also gave much material aid in establishing the Royal Institution and the Mechanics Institution. He was a strong supporter of the Liverpool and Manchester Railway project in 1825 and in the use of locomotives as being more suitable than stationary engines for railways. Dyer's enterprises were on a grand scale and he often suffered great financial losses. His later years were devoted to science, literature and politics. He died at Manchester on May 3, 1871.

1810. There are two additional patents on the nail machine registered in Dyer's name in England, one was dated March 4, 1812, and another two years later, dated April 1, 1814. The first British patent specification of 1810 forms a bulky document, consisting of twenty-nine printed pages and eight sheets of detailed drawings.[58] The operation for making nails on this machine was probably much the same as the Perkins machine of 1799 but with the improvements which time and experience had suggested to the inventor. Bishop, in his history of American manufacturers, says: "The mechanism of Perkins and Dyer was soon after put in operation at the Britannia Nail Works in Birmingham, which was the first manufacturer of cold cut nails by machinery in that country. Its features were those of powerful rotary pressers or hammers for squeezing metal rods into the forms of nail shanks, pins, screw shafts, rivets, etc., of cutters for separating the proper length, and of dies operated by revolving cams or cranks, for forming the heads by compression."

An extract from the Dyer specification of the principal parts of the nail machine shown on Plate IX is given below:

When the back end or tail of the great lever is made to rise, the branch P, P, will cause the toggle N, N, to push against the slider D, D, which will impel forward the cutter L, L, so that its edge acting with that of the cutter K, K, will cut a shive or nail (the person tending or feeding the machine having first introduced the end of the nail plate between the edges of the said cutters, as hereafter described, which nail being thus cut, will find itself in the conducting box *i, i,* and as the lever continues to rise, X, X, will cause F, F, to turn on its axis at G, G, and thereby carry the small slider H, H, downward, and with *h, h,* will force the nail through the conducting box *i, i,* as it advances forward), so that the nail will pass down between the griping dies and rest on the top of the pressing die *e, e,* and at this moment D, D, continuing to advance as the lever rises, will bring the griping die *n, n,* forward, so as to hold the nail fast, and press it between the dies *m, m,* and *n, n.* The lever still continuing to rise, will bring the pieces Y, Y, in contact with the screws Z, Z, which will carry up the pressing die *e, e,* and impress a head to that part of the nail which remains below the griping dies. The great lever being now made to descend, will pull the straps M, M, which will draw back the slider D, D, and thereby open the griping dies and lessen the nail; and as the lever continues to descend, the slider D, D, returning, will draw the conducting box *i, i,* (with the finished nail in it) back, so that the nail head shall no longer continue to repose on the pressing die *e, e;* at this moment *r, r,* will meet *s, s,* which will pull back *q, q,* and turn the lever *p, p,* on its axis, which will open the lower end of the conducting box, so as to release the nail and let it fall and pass off from the machine through a hole made in the body B, B, just under where the nails are released from the conducting box. To the bottom of this hole a tube is fixed, through which the nails are conveyed away as fast as they are made, and thus, as often as the said lever is made to go up and down, all the active parts of the machine will be put into successive operation, and made to perform their due and respective offices of cutting, heading, and discharging one nail at each rising and falling of the great lever, as described.

In Fig. 11, different sizes of the nails, as made with the aforesaid machines, are represented, whose shape I have endeavoured to describe. These are the kind of nails to the manufacture of which the said machines are more particularly adopted; but from the mode of cutting and heading them, and by means of the several regulators and adjusters connected therewith and already described, it will be seen that great variety of form, proportion, and size may be given to the nails with the said machines. I will, however, here observe, that I consider it among the most important branches of the said Invention, to manufacture nails possessing the particular form and qualities of those which I have described and delineated, as I conceive these nails to be far superior, for many uses, to those which are wrought in the

[58] This specification was unobtainable from the British Patent Office but through the courtesy of the Patent Office in Washington, a photograph copy was made of the whole specification from an original on file. In addition to the British patent obtained by Dyer on July 26, 1810, #3365, a supplementary one was taken out on March 4, 1812, #3543 and yet another to supplement this on April 1, 1814, #3798.

usual way with the hammer, and to be equal with these last in every respect, except, perhaps, for those kinds of work which requires the nails to be clenched, and in this respect my said cut nails will be somewhat more liable to break if they are cut, as before described, from nail plates that have been rolled down in narrow strips; but in order to provide for this quality, also, in my said cut nails, when it is intended to make nails that is required to be clenched, I have the iron or other metal rolled into plates as wide as they can conveniently be made, and then have these plates slit or divided transversely into strips or plates, and the nails cut from these strips or plates will have their strata or fibres of the metal disposed longitudinally or lengthwise of the nails, which will render them as flexible as those which are wrought from nail rods, and equally susceptible of being clenched; and the superiority of these cut nails over those made in the old way consists in their flattened or chissel-formed points, and in having two of their sides parallel, which, by placing the said flat points crosswise of the grain of the wood, they may be driven without splitting the wood, in most cases, when it would require to be bored to drive the nails that are made in the old way, with all four of their sides tapering; and as the principal pressure of these cut nails in driving will be on their two converging or tapered sides against the ends of the fibres of the wood, the elasticity of the wood, in the direction of its fibres, will cause the nails to be held in it more firmly when driven, and a little roughness, which in cutting is given to the nails, will also cause them to be held more firmly in the wood. I generally make the heads of my said nails flat on their tops, which forms a plain or uniform surface with that of the wood when they are driven, and of course make a better finish, or, at least, require less putty than is necessary to finish work in which the nails with raised, or as they are called, rose heads, are used; but when it is required to make these rose or any other formed tops to the heads of the nails, with my said machine, it is only requisite to cut or sink the figure of the said head, as desired, in the flat surfaces on the upper side of the pressing die before described, and thereby form dies which will impress the said rose or other forms to the heads of the nails, and by carrying the figures of these dies the heads may be varied at will.

The form of these cut nails reproduced from the specification and referred to in the foregoing description, is shown below.

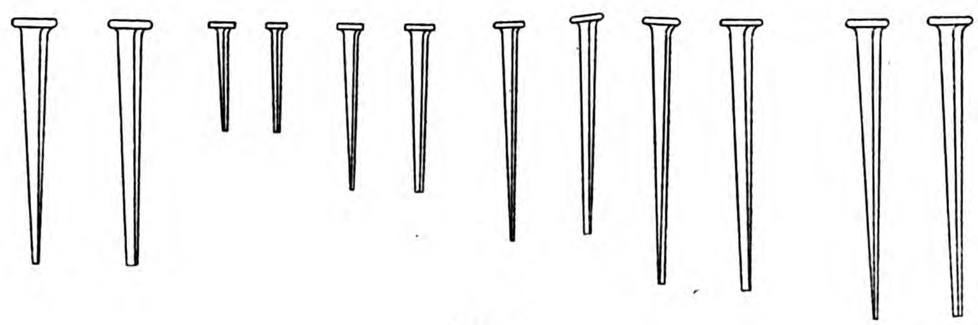


FIG. 11

Shortly after Dyer returned to London, in 1811, he went to Birmingham to have the nail machines constructed and put into operation. Birmingham was even by that time a thriving city of factories where almost every article known to the commerce of that day was made. John George Bodmer, the celebrated Swiss engineer, during a tour of England in 1816 said in his diary: "The number and variety of workshops in Birmingham are immense but they are worked rather ill than well." He at this time went to see the Perkins and Dyer nail machines but somehow failed to gain admission. Manufacturers often occupied, or even shared, a single floor in some immense brick building which was rented out in sections termed "factory flats," with a single steam engine used in common by all the tenants who wanted power for their machinery. Such a building was the Britannia Brewery

on Blews Street, just off Newtown Row. After this had ceased to be used for the making of beer, it was converted into a factory and called Britannia Buildings, where several tool-makers and machinists' workshops were located. Here Dyer obtained space to establish the nail-making machinery. Between 1812 and 1814, presumably, the nail-making business was getting under way, but of this nothing is definitely known for these years are not covered by the Birmingham directories. However, in the directory for 1815 there is listed under the heading of nail works "Williams, Jones and Company, Britannia Buildings" which might indicate that the Perkins-Dyer nail machinery was by then in full operation though no longer under Dyer ownership. From 1816 to 1820, this concern is listed as the "The Britannia Patent Nail Factory." Between 1823 and 1835, it was owned by Winkfield and Company, with some changes in the firm name. From 1839 to 1867, it was known as the "Chunk Nail Company, Britannia Works." By 1872 the old factory was acquired by Reynolds and Sons, manufacturers of cut nails. This firm, we understand, is still in the same location at the time of writing. The present address is 178 Newtown Row. Though the Perkins and Dyer nail machines have long since been superseded, their fundamental influence still remains. In 1812 a nail machine could perhaps produce 100 nails per minute providing the mechanism did not clog up at this speed. By comparison, a modern nail machine making wire nails can easily turn out half a million nails a day.

In addition to the Perkins nail machine which he introduced into England, Dyer also took out a British patent for Perkins' invention of copper plate printing and method of preventing counterfeits (Patent of June 16, 1810). The Dyer British patent is dated April 1, 1811 and in the specification of this, he fully credits Perkins with the invention.

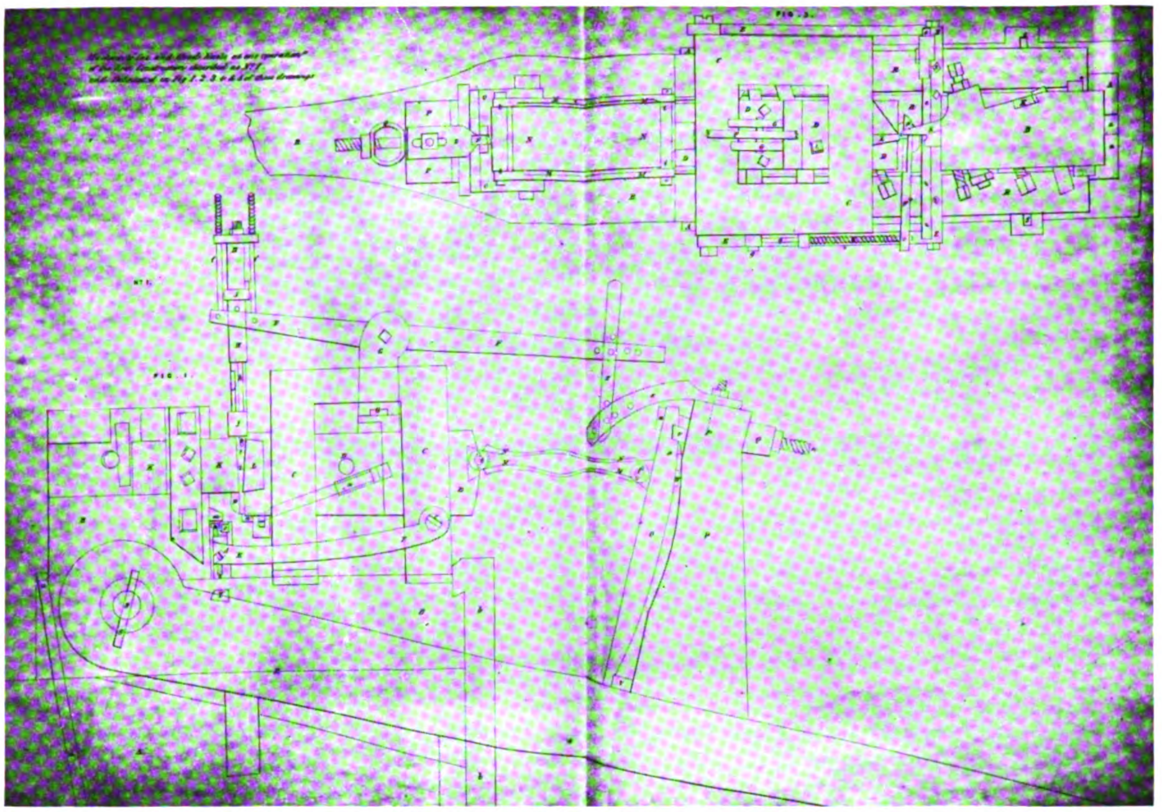
An echo of the old Amesbury days is to be found meanwhile in Perkins' petition to Congress in 1813 for a renewal of his 1799 nail-making patent, for a further fourteen years. The reason for this somewhat belated request on his part is to be found in the fact that sometime in 1812 William Gray, one of the proprietors of the Amesbury Nail Factory at this period, had given back to Perkins his patent without compensation. This seeming generosity on Gray's part upon examination however reveals itself as not quite so magnanimous as might be supposed at first glance. The patent was of doubtful value to either man as unless it could be extended for a further period, it would have been no further use at the Amesbury mill. Perkins seems to have thought "nothing ventured, nothing have," and drafted a petition to Congress which he proposed delivering in person.

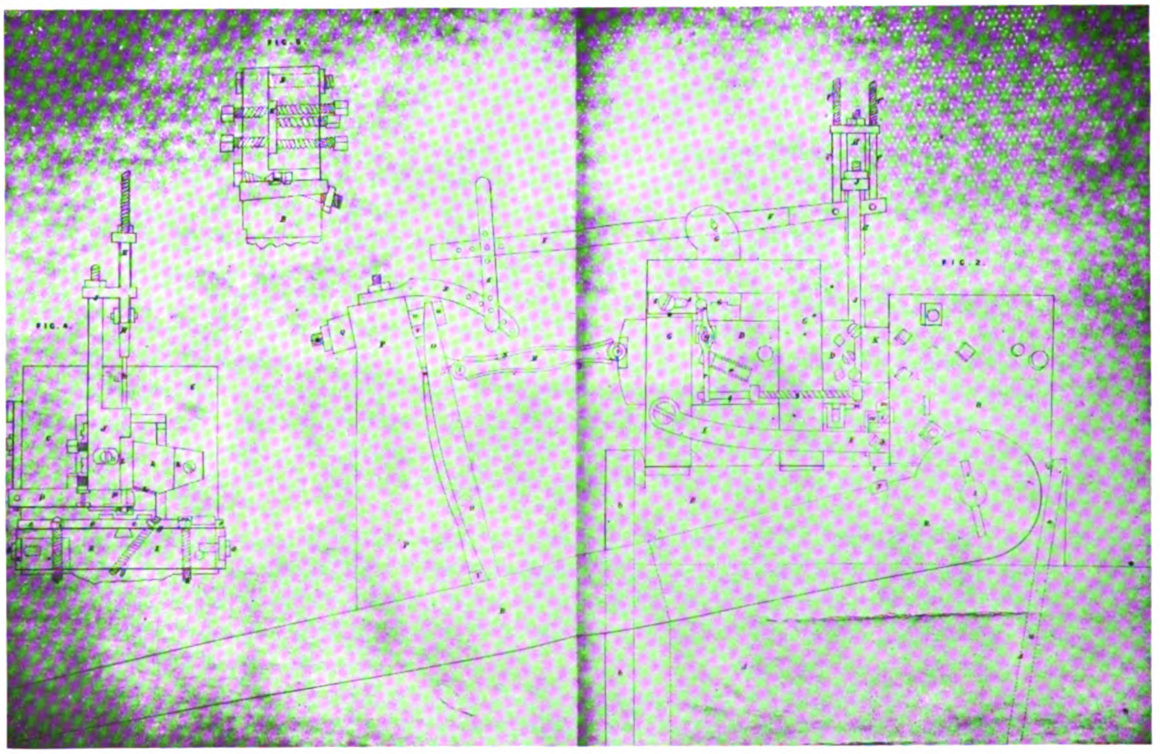
Before setting out on the long journey to Washington, Perkins enlisted the sympathetic support of David Humphreys,[59] then residing in Boston, a man who had served the Federal Government well in the past, as soldier, foreign secretary and statesman. Having urgent correspondence with President Madison in connection with the progress of the war, he suggested that Perkins convey his letter to the President, which would serve the useful purpose of introducing Perkins to Mr. Madison's notice. Humphreys' letter to the President reads as follows: [60]

[59] David Humphreys was born in Derby, Connecticut, in July of 1752. He was aide-de-camp to Washington from 1780 until the close of the war. In 1784 as Secretary of Legation to Benjamin Franklin, he spent two years in Paris and London. At the beginning of the War of 1812, Connecticut appointed him chief commander of two regiments with the rank of Brigadier General. He retired from all active duties in 1815 and died at New Haven, Connecticut on February 21, 1818.

[60] From a holograph letter in the Manuscript Division, Library of Congress. The periods indicate the omission of about five pages which dealt with the current political situation.

The Perkins and Dyer Nail Machine of 1810, described in the specification.





From a copy of the specification in the United States Patent Office.

Boston Feby 19th 1813

Sir

Mr. Jacob Perkins of Newbury Port will have the honour of delivering this letter into your hand. He is the author of several ingenious and useful inventions. As such I beg leave to introduce him; with the farther information, that the object of his journey is to obtain from Congress the renewal of a Patent about to expire; and that I have given him a Certificate expressive of my opinion of the great Service which he has rendered to the Community by introducing the Carding-Machine: from which, I understand, he has derived no emolument. Altho this fact may not be altogether sufficient to entitle him to *favour* on a different subject; yet it will shew at least that he is one of our meritorious Citizens & not unworthy of *such* as may be granted without the infringement of or deviation from, the principles adopted for the conduct of the Patent Department. . . .

Mo: obe: servt:
D. Humphreys.

P.S. It will be discovered this was intended to have been forwarded by Mr. Perkins, which will account for its arriving so long after its date.

Perkins seems to have delayed the delivery of this letter unnecessarily and Humphreys was forced at last to send it by other hands. When Perkins finally got to Washington, it was early summer and his chances of making a good impression on Madison, had passed. His petition reads: [61]

PETITION.

To the Honorable Senate, and the Honorable House of Representatives of the United States of America, in Congress assembled: THE PETITION of Jacob Perkins, of Newburyport, in the county of Essex and Commonwealth of Massachusetts.

RESPECTFULLY REPRESENTS,

THAT while the manufacture of cut nails was very imperfectly understood in these United States, and as your petitioner believes, wholly unknown in Europe, by the labour and study of several years bestowed on that branch of manufactures, he invented numberous improvements, the value of which has been fully ascertained, and was the first person who obtained letters patent from the government of the United States for making cut nails by water machinery.

That in consequence of the small degree of encouragement afforded, at that time, within the United States to manufacturing establishments, as well as with a view to extend his sphere of knowledge of useful manufactures, your petitioner was induced to form a connection in business with John Warren Armstrong, of Bristol, in England, an eminent merchant and manufacturer, to whom he conveyed in mortgage the several patent rights which he had previously obtained for the various improvements in the manufacture of nails, as collateral security for monies furnished to your petitioner by the said Armstrong, and expended in the prosecution of the said manufacture.

That the said patent rights with the factory buildings, machinery, and implements belonging to the same, in which your petitioner had a valuable interest, was afterwards, in consequence of misfortunes sustained by said Armstrong, conveyed away by him by assignment of said mortgage, without notice to your petitioner, whereby, at the expiration of the term limited in said mortgage, your petitioner, was wholly deprived of the patents and property above mentioned, and of all the avails of many of the best years of his life.

Your petitioner would beg leave further to state, that some considerable time afterwards the said patents came into the possession of the Amesbury Nail Factory Company, of which the honorable William Gray is a principal proprietor; which company, with great liberality and without any pecuniary compensation, reinstated your petitioner in his right to one of the aforesaid patents, to wit, of that bearing date February 14th, 1799.

[61] Petition of Jacob Perkins, of Newburyport in Essex County, State of Massachusetts, for a renewal of his Patent Right to a Nail Cutting Machine. June 15, 1813. Referred to a select committee. Washington, A. & G. Way, Printers. 1813. (From Public Documents—1813, 13th Congress, 1. Session.)

This your petitioner considers the most important of his patents. To the machinery constructed in conformity with this, during the four years last past, and since the reconveyance to himself above stated, your petitioner has devoted much time and attention, labour and expense, thereby increasing its value and importance; and with this machinery he may now safely say, that he is able to furnish cut nails in every respect equally excellent with any which have been made in any part of the world.

For the labour and expense bestowed on this machinery, your petitioner has not hitherto received any equivalent, and without the interposition of your honorable body all his hopes of remuneration must fail by the expiration of the term of his said patent, which took place on the 14th day of February last.

Your petitioner would further state, that he came to this city the latter part of the last session for the purpose of petitioning your honorable body; but in consequence of his having been detained by the badness of the roads and other unavoidable circumstances, he arrived too late to present it.

Your petitioner trusts that it will not be thought unbecoming in him, on the occasion, and in support of the appeal which he presumes to make to your honorable body, to state, that his time has for twenty five years past, with little interruption, been devoted to the pursuit of improvement in mechanics, principally as applicable to the manufacture of articles of necessity and principal importance; and that during that period, although he has not been exempt from difficulties and embarrassments, and more especially during the earlier part of it, when the importance of manufactures was far less appreciated than at present, he has succeeded in making improvements in the following branches of manufacture, viz.

Silver plating, fire engines, pumps, jewelry and other silversmith work, copperplate printing, security of bank notes against counterfeits, nails and brads, morocco finishing, screws, locks, presses for cotton and other goods, silver spoons, improvement in water wheels.

All of which, with the exception of the cotton press, spoon machines, and improvement in water wheels, which have been but recently invented, have been brought into extensive use in Massachusetts and the neighboring states, and your petitioner has reason to believe have proved of public advantage.

Your petitioner also begs leave further to state that he has from time to time introduced from abroad various improvements in manufactures, and that in the year 1794, he brought into use in the United States the machine to card wool, in the same improved state in which it is now found in our principal manufactories.

Yet, although your petitioner hopes and believes, his inventions and improvement have produced and are producing important benefits to his fellow citizens and his country, and although the profits which he has from time to time realized, have been far from inconsideralbe, these profits have been considered valuable, principally, as they have constituted a fund enabling him to pursue new improvements, and have not contributed to his personal emolument.

Wherefore your petitioner humbly prays your honorable body, that by granting to him the exclusive right secured by him by the said letters patent, bearing date February 14th, 1799, for the further term of fourteen years from the expiration of said patent, or for such further term as in your wisdom may seem meet, you would afford to your petitioner some indemnity for his past labors, losses and disappointments, and furnish him with the means to follow that course of pursuits to which he has long devoted himself, and to which he is attached as well by strong native inclination as by the desire of rendering his time, his talents, and his studies useful to others.

And as in duty bound your petitioner shall ever pray.

Jacob Perkins.

Perkins journeyed to Washington to present this petition personally but unfortunately he was too late to have it included in the session. His request to have the nail machine patent extended was later refused by Congress on the grounds of public policy, insomuch as the patent had already lapsed and was by then public property.

Of the inventions and patents referred to by Perkins in his petition, many have been dealt with already. Several others which he mentions, including his reference to the carding machine, may now be considered.

The roller carding machine was the invention of Richard Arkwright, of Nottingham, England, who perfected it between the years 1773 and 1775. And it was without hesita-

tion adopted by the British textile trade. Its sound principles prolonged its usefulness well into the nineteenth century. In 1787 a company in Beverley, Massachusetts, imported several spinning jennies and an Arkwright carding machine.[62] The company, however, failed before they could get under way. Of Perkins' part in the furthering of the carding machine in Massachusetts in 1794, it may be surmised that he introduced it first at the Byfield woolen mill and shortly afterwards, into the woolen and felt manufactory at Amesbury, the premises of which Perkins had bought to use in part for his nail factory. A reference to this from an advertisement in the *Herald* dated July 5, 1799, reads:

"CARDING MACHINES, HATTERS' WOOL, and ROLLS, carded in the neatest manner and on the lowest terms at the Nail Factory, Amesbury Mills."

Two patents were taken out during this year, 1813, which centered on the principle of rolling, though these were for widely divergent purposes. The first was a roller transfer press or copying machine for more efficiently impressing steel and copper plates by a circular matrix or master die dated June 25th and a device for manufacturing silver spoons by shaping them between a steel roller and a movable table, each of these parts having respectively the impression of the two sides of the spoon. A rack and tooth wheel synchronized

Silver marks (enlarged) of Theophilus Bradbury and Son in 1815. Spoons of this period bearing these markings were probably all made by means of Perkins' Roller Press.

the movement between the table and roller. The soft silver blank passing between these dies was patterned and shaped in one operation. This last invention is dated June 29th. In this machine for making spoons, Perkins' inventiveness again reverted to his original profession, and there seems little doubt that he had not entirely abandoned it. He was a great friend of Theophilous Bradbury, the silversmith, of Newburyport, who did so much to raise the standard of American made silverware. In 1815 Perkins stated that he had examined specimens of Bradbury and Son's work and pronounced them equal to European manufacture. Without doubt Perkins, with his knowledge of diemaking, simplified much of the repetition work performed by this firm. Perkins was always considered by his New England contemporaries as belonging to the precious metals trades. In a published address in 1818 by the Massachusetts Charitable Mechanics Association, of which body Perkins was a member, his name is given in the classified trades list as a goldsmith, a statement to which evidently Perkins himself concurred.

The cotton press mentioned in the petition was patented in 1819 under the title of the "Progressive Lever Press." A few details of the construction are available and these will be referred to later on.

At this time one of the greatest mechanical hoaxes of its day was being foisted on a credulous public by Charles Redheffer, of Germantown, adjacent to Philadelphia. In 1812 he had constructed a machine in which weights placed on two inclined planes, mounted on a horizontal wheel, were supposed to revolve by their own gravity.[63] This contraption was

[62] *History of American Manufactures* by J. Leander Bishop, Philadelphia, 1861.
[63] A model of this machine is on exhibition at the Franklin Institute in Philadelphia. The original imposture was worked by a concealed operator in an adjoining room.

called a "self-operating and self-moving machine," by the inventor. Redheffer first gave demonstrations in his home at an admission charge of $5.00 per person, "female visitors gratis." He became a protégé of William Duane, the publisher of the *Aurora* and soon the whole reading public was divided into two camps, for and against the inventor and his machine. It was even seriously considered utilizing this new found power to pump water for the city at Fairmount. In February, 1813, Redheffer, being faced with the necessity of definitely proving his discovery, removed himself and his invention to New York where he hoped the doubtful reputation of his machine had not preceded him. Charles Gobert, a civil engineer of Philadelphia, who had invested heavily in the "great Discovery," tried in vain to reproduce on a large scale the movements of Redheffer's machine. During the further demonstrations in New York, Perkins had found the opportunity to attend and with quick mechanical perception he informed the audience in general and the inventor in particular, that if a saw was passed through one of the supporting legs of the machine, the source of power would be revealed. Needless to say, Redheffer refused to permit this candid suggestion to be carried out. Gobert, who was more than willing to back his opinion against Perkins' imputation, proposed to wager on it as a news item in the Boston *Daily Advertiser* reveals:

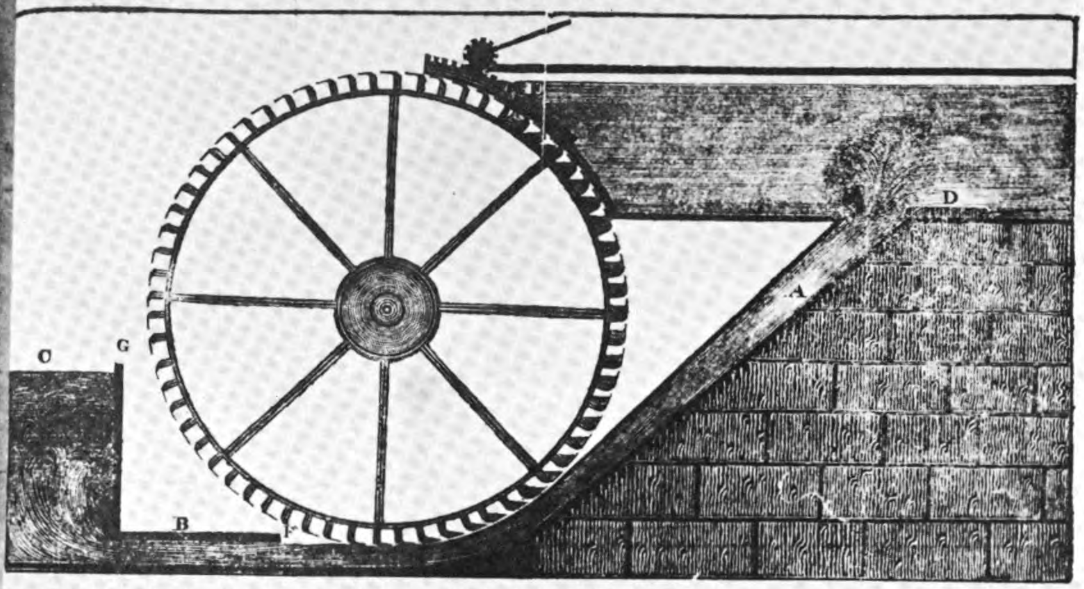
> Mr. Gobert of Philadelphia, who lately advertised that he would take any bet from five to one hundred thousand dollars on the feasibility of Mr. Redheffer's discovery of perpetual motion was taken up for five thousand dollars, by Mr. Jacob Perkins of Newburyport—after making a series of experiments in vain, to construct a moving machine upon Mr. Redheffer's self moving principle, he discovered to his infinite chagrin, that Mr. Redheffer had in the meantime moved himself off, with 20,000 dollars in notes of hand given him by Mr. Gobert for his valuable secret. We understand that Mr. Gobert has acknowledged his bet forfeited and is now in pursuit of Redheffer, who keeps himself in perpetual motion to elude him.

It is, however, extremely doubtful that Perkins ever collected his debt from Gobert. Redheffer, after a safe lapse of time, again reappeared in Philadelphia with an "improved" machine and in 1819 was soliciting support to enable him to obtain a patent from the Government, but by now public interest had waned and Redheffer's pretensions as a great discoverer lapsed into oblivion. After a decent lapse his supporters took the machine to England, where it again came under the notice of Perkins, in 1824.[64]

On June 26, 1813, Perkins obtained a patent for "improvements in water mills" by relieving the tail race of excess water. Under abnormal conditions of freshet and flood which so often beset the early manufacturer using water power, the water would back up into the race under the wheel and greatly impede the free rotation of the buckets. As there was always an abundance of water at the mill dam during these critical periods, Perkins devised a separate water chute which would pass the excess water downward at a steep angle from the penstock and by converging it into the tail race, this would by its velocity

[64] From the *Mechanic's Magazine*, Vol. 2, 1824. Quoted under "A Perpetual Motion Imposture from America." This says, "the inventor of this wonderful wonder having lately honoured the city of Norwich with a visit for a short time the Mayor thought proper to direct a friend in London to inquire whether Mr. Perkins knew anything of this American prodigy. Mr. P. told the inquirer that he had once actually travelled 400 miles in America to see a piece of mechanism which he believed to be similar, but that having found it to be all of a deception."

Improvement in Mills for the purpose of removing Back Water.



THE Subscriber has recently obtained a Patent for an Improvement in Water-Mills, which, from actual experience, ha. .een found to be of great importance; it consists in the complete removal of all the inconveniences heretofore experienced from back water.

is a well known fact, that in most situations it has been found necessary to place water-wheels from one to three feet higher than they would be, it not requisite to avoid the back water, occasioned by freshets and high tides. In nearly all cases there is a serious loss of power, but more cially so where it consists of a few feet only. The patentee has satisfactorily proved, that with a head and fall of twelve feet, six feet of back r may be driven away, and with it, all the water which has been expended in moving the wheel: there is therefore, no exaggeration in declar- that taking into the account the time that many mills are stopped by back water, and the permanent loss of power from the height at which the els are hung in order to avoid this difficulty; from one fifth to one third of the power is absolutely lost, an evil which is completely obviated by Invention.

All the time when the wheel is retarded by back water, a large quantity is constantly running to waste; this Invention accomplishes its removal by application of a portion of this superabundant water, which would otherwise run over the dam.

The above Section will shew the operation of this principle in removing back water. The construction of the floom, and raceway, differs from the mon form, by having a tight tube, A, running from the bottom of the floom, as at D, to or past the centre of the bottom of the wheel, and of a- four times the size of one which would be necessary to turn the wheel. The size of the tube may vary according to the back water common he mill. The lower end of the main tube, A, being in a direct line to that of the horizontal tube, B, will direct the water which rushes down former through the latter, and at the same time overcome the pressure of the water and atmosphere at C, so that the atmosphere may act upon back water which had collected round the bottom of the wheel, and force it through the tube, B, which being one third larger than tube A, will t enough of the back water at the opening, F, to fill the tube B, and thereby in a few minutes, to entirely remove it from the bottom of the wheel; the water which has been expended in moving the wheel, will join the current at F, and pass off through the tube B. The bulk-head, G, must above the extreme height of the back water, for as there is no other passage for the water to escape from the wheel, than through the tube B, e should be no other through which, in times of back water, it can pass to the wheel. When the freshet is over, and the water has found its lowest l, the horizontal gate, D, should be shut, and the water which carries the wheel will run off through the tube B.

This method of removing back water, will not apply to tide mills, except where there is a great surplus of water; in that case, by adopting this , the mill may be made to go sooner and later than it otherwise would. Whe e the tide rises at the tail of a common mill, this principle may be lied to great advantage, as the wheel in many situations, may be set 2 or 3 feet lower than it commonly is, and by driving off the back water occa- ed by the tide, the extra power which is gained by increasing the fall, will be much more than the loss of the water expended in drawing off the k water at high tide.

Communications upon the subject of this Improvement will be gratefully received, and immediately noticed by the subscriber, the patentee, of wburyport, Massachusetts, or by Dr. THOMAS P. JONES, Philadelphia. JACOB PERKINS.

October 4 2aw1m1s

A Business Circular concerning the removal of backwater from mill wheels. Jacob Perkins' Patent of June 26, 1813. *Reproduced by courtesy of* The American Philosophical Society, Philadelphia.

carry all before it, and so clear or lower the dead water under the wheel. This invention does not seem to have been very generally adopted, that is, as far as definite records show. A wheel on this principle was, however, installed in a large cotton mill of seventeen hundred spindles at Waltham, Massachusetts, which was owned by the Boston Manufacturing Company.[65] Perkins, writing in the *Newburyport Herald* in 1815, says of this mill: "That his method of removing the back water arising from freshets has been tried during the whole of the winter on a large scale, at the new and extensive Cotton Factory in Waltham, near Boston. It is fully proved that the water wheel may be placed as low as the lowest level in the driest time, and that any freshet which occasions back water, will also furnish much more than a sufficient supply of water to remove the back water. At the above factory, the fall is about ten feet, and the back water has often for a long time exceeded three feet, which has with ease been removed by this method. The current of water which drives off the back water does not come in contact with the wheel; of course it will have the same power as when no water exists. The object is to produce an equable power, and more full, which is fully obtained." A business leaflet used by Perkins to encourage the adoption of his improvement to water wheels is shown on Plate X. Perkins was later awarded the Vulcan gold medal for his ingenious idea by the Society of Arts in London. Additional drawings of this wheel, which were published in the Society's journal in 1820, are given in Appendix G.

Amid all his divergent interests and inventions which flooded this particular period of his life, Perkins had not neglected the possibilities of making a strong business connection in Philadelphia to further siderographic printing. His friend, Gideon Fairman, as a partner of Murray and Draper, had already paved the way for closer business connections with his firm. It has not transpired under what circumstances nor where Perkins and George Murray, the senior partner, met for the first time, but it could scarcely have been earlier than 1810 nor later than 1812. A partnership of some sort, however, was entered into between these years and two patents were sealed in their joint names. The first was for the circular matrix transfer press of June 25, 1813, which has been previously referred to in these pages. The second patent was for a printing press for copper and steel engravings which is dated June 29th of the same year. In these patents Perkins' residence is still given as Newburyport and that of Murray is Philadelphia.

After Perkins had attended to his patent business in Washington, he came on to Philadelphia for a brief stay of "eight or ten days," which visit was intended to be used to drum up business for his newly patented "improvement in water mills."[66] Perkins stayed at the home of Gideon Fairman at 28 Sansom Street and undoubtedly there was between them much discussion as to the financial gains which might accrue from the two patents so recently sealed. By the middle of July, 1813, Perkins started homewards to Newburyport and on his way north, he probably stopped off at New York long enough to confound Redheffer and his perpetual motion machine.

Perkins was now forty-seven years of age and with the maturing of his material ambitions had come the urge for a fuller knowledge of philosophical and practical science. In Boston at this time there was a society which was considered as representative of the most intellectual advancement of that day. This gathering of savants was known as the

[65] Bishop: *History of American Manufactures.*
[66] From the *Aurora*, July 7, 1813.

American Academy of Arts and Sciences and they held their meetings quarterly, either in Boston or Cambridge. These meetings were quite informal and took place at the houses of the various members. The Academy even at this time was an institution of long standing, having received its charter of incorporation on May 4, 1780, and its first president was James Bowdoin, later Governor of Massachusetts in 1785. Perkins was elected to membership in the Academy at the meeting held August 15, 1813, in Boston. At the next meeting, which occurred on November 19th, the following announcement is recorded in the minutes:

> The proceedings of the last meeting were read, also letters of acceptance from William Sullivan, Esquire, Rufus Wyman M.D. & Mr. Jacob Perkins.

Perkins' letter of acceptance reads: [67]

Newburyport, Sept. 2, 1813

Hon. Josiah Quincy
Sir:

I have received your favour of the 19th ult. informing me of my having been elected to be a fellow of the American Academy of Arts and Sciences.

Were it not that the Academy, by their recent election determined otherwise, I should have supposed that my standing in life, & limited knowledge of the sciences, would not have entitled me to so high an honour, which could have been the only reason why I should not wish to become a member of that respectable body.

I have enclosed five dollars in conformity to the regulations of the Academy.

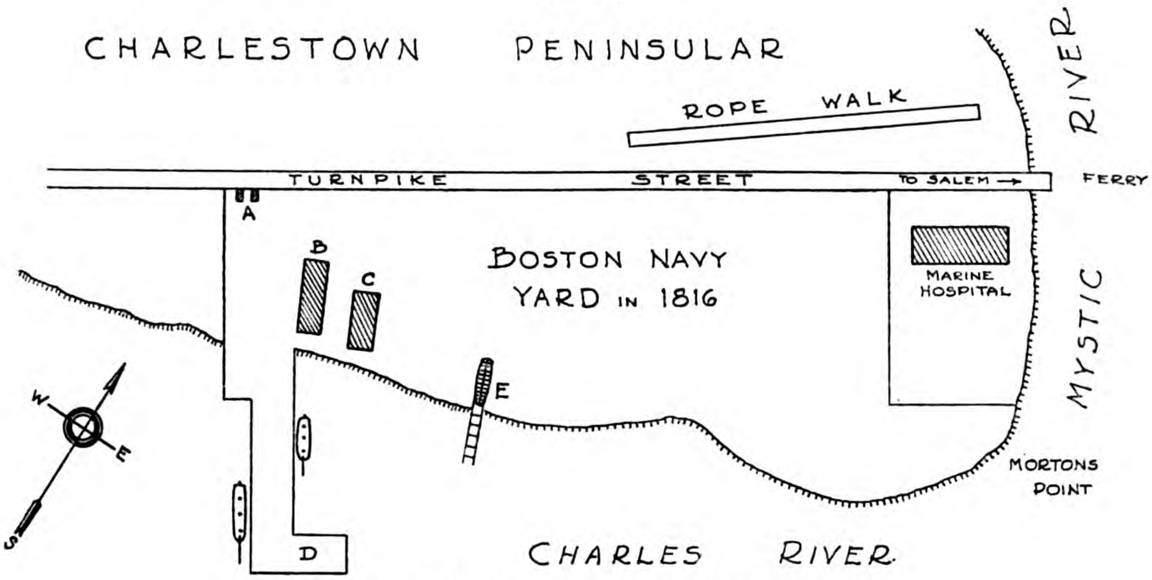
I am, Sir
very respectfully
your Obt. Servt.
Jacob Perkins

It appears from this letter that Perkins was somewhat overawed by thoughts of how his fellow members might regard him. He seems unusually diffident about his own abilities but perhaps the tenor of the letter merely reflected his appreciation of being elected a member of this body. The minutes of proceedings for this period are very brief, they do not even list the names of members present at the various meetings and the general records of the society do not reveal any further mention of Perkins' name. He apparently never held any office nor did he sit on any committees and he did not contribute anything to the society's journal. Many illustrious names are to be found on the long roster of the American Academy; David Rittenhouse, the astronomer, Sir Humphry Davy and Michael Faraday of the Royal Society are among these, as is also Dr. William Hyde Wollaston who, later in London, when Perkins was newly arrived in a strange land, gave to him his kindly and unselfish support in furthering Perkins' experiments on the compressibility of water and liquefaction of gases.

[67] In the possession of the American Academy of Arts and Sciences, Boston. Josiah Quincy, 1772-1864, lawyer and statesman. Born in Boston. He was in 1813 a member of the Massachusetts State Legislature and also at this time president of the American Academy of Arts and Sciences.

The second war with Great Britain, which had been formally declared on June 19, 1812, was fought almost entirely on the water. At the commencement of hostilities the American navy was almost negligible, consisting as it did of only fourteen vessels (frigates and sloops of war) and a few gunboats. In 1813 Congress appropriated $2,500,000 to construct a series of heavily armed frigates which could be used under any condition of war as ships of the line.[68] Several of these vessels were laid down during the war at various Navy Yards, but were completed too late to take any part in the war, peace having

MAP 4



A—The Dockyard Gates. B—Sail Loft and Store House. C—The Commandants' House. D—The Mole. E—"Independence" on the ways. *Drawing by the authors.*

been signed at Ghent, December 24, 1814. Of these new warships, one was the *Washington* built at Portsmouth, New Hampshire, and another was the *Independence* built at the Charlestown Navy Yard, both of 74 guns. The latter vessel was the most completely equipped warship of any navy in the world. She was constructed under the personal supervision of Commodore William Bainbridge,[69] who at this time was commandant of the

[68] *Independence*, *Franklin*, *Washington*, *Columbus*, *Ohio*, *North Carolina* and *Delaware*. All these vessels mounted 74 guns and were built between 1814 and 1820.

[69] William Bainbridge was born in Princeton, N. J. in May, 1774. He commenced his sea career in the merchant service at the age of fifteen. When the first regular navy was organized in 1798, to protect American commerce, he joined with the rank of Lieutenant-Commandant. In 1805 with the rank of Commodore, Bainbridge was granted leave to return to the merchant service to recoup his fortunes, but he was hastily called back to the navy in 1808 in anticipation of the second war with England. No war occurring, he returned again to the merchant service until 1811. When war seemed inevitable, Commodore Bainbridge was ordered to take charge of the Charlestown Navy Yard but after the commencement of actual hostilities in 1812, he solicited active service on the high seas and he was given command of the famous *Constitution*, a frigate of 44 guns. Wounded in the subsequent fighting, he returned to again take up his duties at the Charlestown Navy Yard and of the defense of Boston. Commodore Bainbridge was the first to advocate a Board of Commissioners for the navy, to be composed of businessmen, shipbuilders and engineers, as well as naval men, and he was the first

Charlestown Navy Yard (1813-1815) but to Jacob Perkins must be given the credit for many of the useful innovations which helped to complete this vessel. Commodore Bainbridge was an officer entirely without prejudices, his long experience in naval affairs had convinced him that the efficient administration of the navy could not be successfully conducted without invoking at times the help of the civilian professional man. To Commodore Bainbridge Perkins' reputation for ingenuity and practical invention was not unknown and he no doubt welcomed and encouraged Perkins' assistance at this critical time.

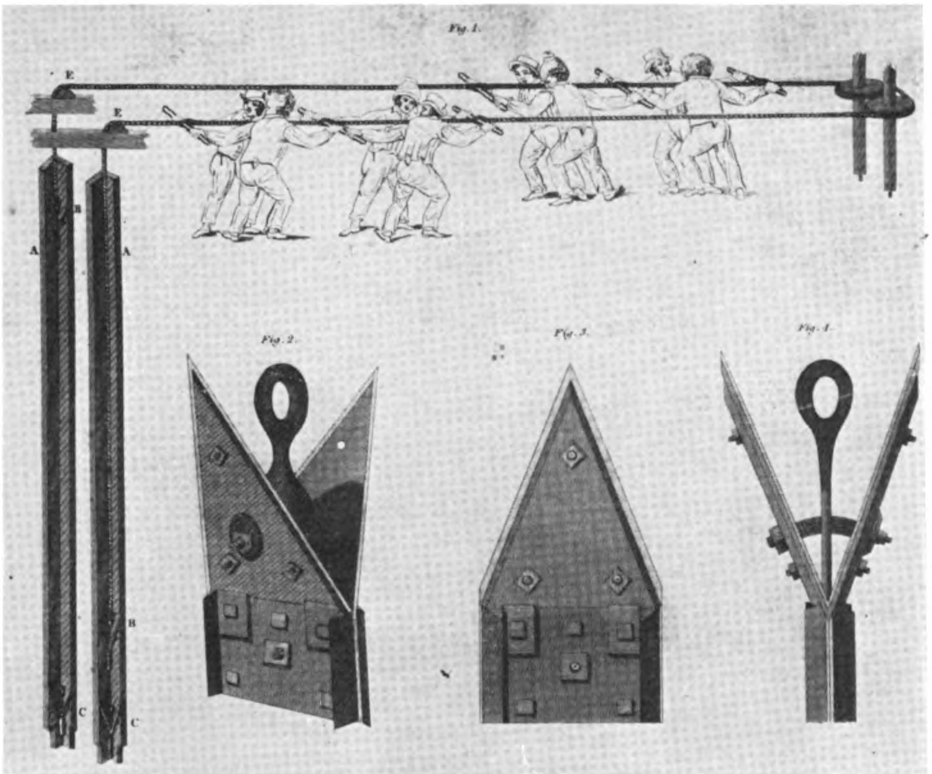
Perkins' contributions to the American navy were varied, and included ship's pumps, instruments to aid navigation, ordnance and ship ventilation.

The Charlestown Navy Yard, Map 4, the scene of Perkins' work, had been first surveyed by Joshua Humphreys,[70] the Philadelphia ship builder, in 1799 and Congress authorized the purchase of the land on June 17, 1800. It consisted of forty to fifty acres on deep water on Charlestown Neck. The cost of this tract was $39,214. The earliest brick building dated from 1803 and was erected near the entrance of the yard. The Commandant's house, also of brick, was built in 1809. The Marine Hospital was commenced about 1813 and later a naval school was established at the yard by Commodore Bainbridge in 1815. The resources of the Charlestown yard were not very extensive and up until the beginning of the War of 1812 consisted of little more than a sail loft, a blacksmith shop and several launching ways open to the sky and until 1820 at least there was but one deep water dock at which ships could be masted. Perkins' first work for the yard in 1813 seems to have consisted of devising methods of reboring the old and much used cannon that lay around the yard, and thereby reconditioning these for further service. Cannon, by reason of frequent firing, became honeycombed, especially at the chamber end of the bore. By reaming out the entire gun the same size shot could then be rammed home wrapped in a piece of thick canvas to reduce windage, an expedient more effective than it sounds. It is not on record that any cannon were made at the Charlestown yard. This work was invariably done by local iron foundries. On Dorchester Neck, now a part of the city of Boston, Cyrus Alger had a furnace and foundry and it is recorded [71] "during the War of 1812 he supplied the Government with large numbers of Cannon Balls." And it is probable that it was here that Perkins constructed the tools for reconditioning a great deal of the Navy's disused cannon and effected improvement in molding the shot. It is probable that nearly all the iron cannon cast in America during the Revolutionary War were not bored but remained practically as they came from the foundry, for the emergency was great and the facilities few. In 1775 the boring of cannon was made compulsory by the British Board of Ordnance and in America by 1798 it had become a prime requisite for all cannon to be machined inside to definite limits. The boring lathe, shown on page 49, on which this work was done

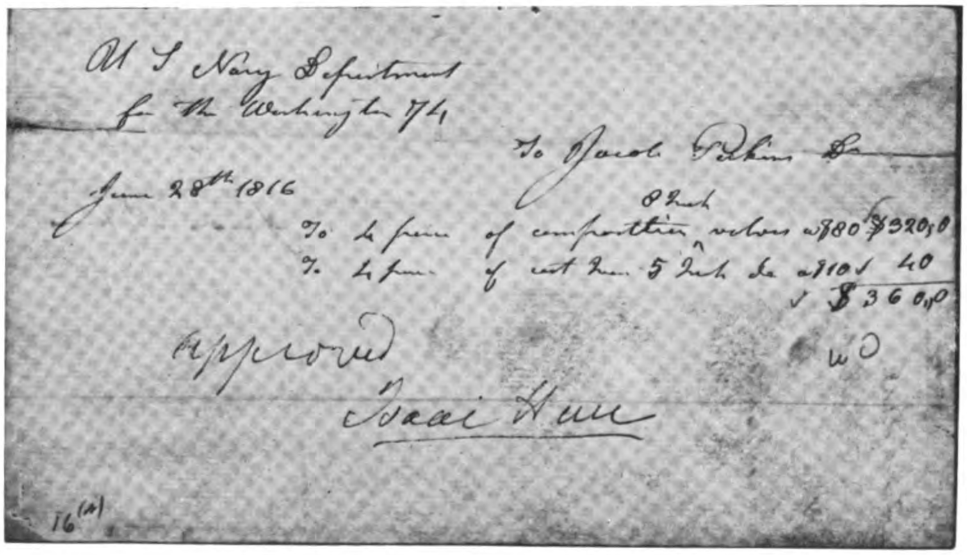
to inaugurate a naval school which was at Boston in 1817, for training officers. He was an exceptional naval officer for his times, for apart from his courage and resource in action, he also possessed a progressive and tolerant viewpoint toward innovations which could improve the service on shore as well as afloat. He was accessible to any man who had something to offer to these ends but he would also depend at all times on his own judgment. His active service continued almost until the time of his death, which occurred in Philadelphia from pneumonia on July 28, 1833.

[70] Joshua Humphreys, born June 17, 1751, at Haverford, Pennsylvania. After the adoption of the Constitution, he became the first naval architect in the country and has been refrred to as "The Father of the American Navy." He built many famous naval vessels, such as *Constitution*, *Chesapeake*, *Congress*, *Constellation*, *President* and the *United States*. This last at his own shipyard in Philadelphia. He died January 12, 1838.

[71] Bishop: *History of American Manufactures.*



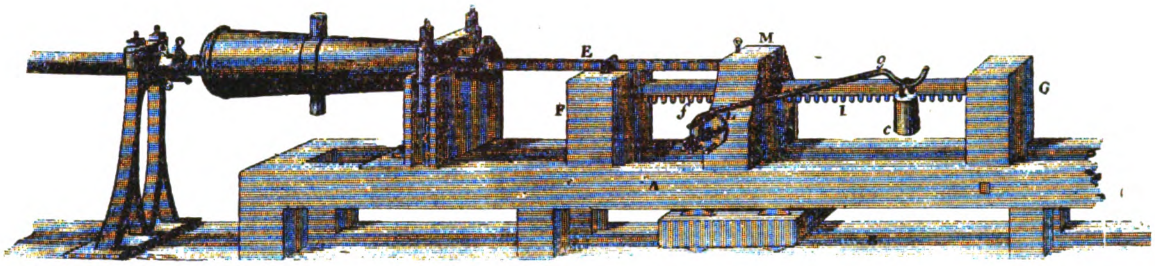
Engraving of Jacob Perkins' Ship's Pump, from Rees' *Cyclopedia.* AA the wooden pump barrels shown in section. BB and fig. 2 are the bucket valves. CC and fig. 3 are the foot valves. Fig. 4 shows the curved bolt that limits the sweep of the valves against the sides of the pump.


U S Navy Department
for the Washington 74
To Jacob Perkins Dr
June 28th 1816
To 4 pair of composition valves 8 Inch a $80 $320,00
To 4 pair of cast Iron 5 Inch do a $10 40
$360,00
Approved
Isaac Hull
16(a)

A Bill for Pump Materials for the *Washington,* rendered by Jacob Perkins to the Navy Board in 1816. *Reproduced by the courtesy of the* General Accounting Office, Washington.

was extremely crude and here no doubt Perkins found much scope for his ingenuity in a class of machine work that still left much to be desired.

Perkins obtained a further patent on March 23, 1813 covering fire engines and pumps. This pump with a novel form of valve, was first installed on the *Independence* in 1814, for pumping the bilges,[72] and they were quickly adopted by many shipbuilders and approved by numerous ship captains because of their reliability in working and the simplicity of materials used, for, except for the metal valves, the entire pump could be constructed of wood. In its original form, the pump barrel was merely four square boards spiked to-



A Cannon Boring Machine of the Period, War of 1812.

The frame AB supporting the rack I fixed between the uprights FG. The sliding block M and the boring tool E. The mechanism f.g.c. that turns the shaft L which by means of a pinion engaging the rack moves the boring tool forward as the cannon revolves.
From Rees' *Cyclopedia.*

gether at the corners. The foot valves and the valves forming the bucket were triangular pieces of hinged metal faced with leather, which closed down at an angle into the corners of the box shaped pump barrel, the weight of the water keeping them in close contact. The component parts of Perkins' pump can be readily gathered by referring to Plate XI, which shows its application on board ship. An account of a demonstration of this pump, printed in the *Newburyport Herald* in 1815, reads as follows:

TRIANGULAR VALVE PUMP.

We have lately attended an experiment made with the triangular valve pump lately invented by Mr. Perkins. It is found to deliver double the quantity of water of the best chain pumps,[73] with the same number of men, with much less exertion and fatigue, by a new application of the power. Two holes, each two inches in diameter, were made between the floor timbers of a brig, and the water let in through these holes in 16 minutes, was discharged by this new pump in one minute.

An astonishing difference between this and the common pump. A particular description will not at present be given, as the inventor, we understand, will shortly send to England and France for patents.

From experiments made in our river, we have no doubt that the inventor will succeed in making

[72] In 1836 the *Independence* was cut down to two decks with 54 guns. At the time of this alteration, the vessel was furnished with two chain pumps (see Ewbank, p. 156). It is stated that the earlier equipment was still retained, which would indicate that Perkins' pumps had already twenty years of service to their credit.

[73] In the American navy, opinion seems to have fluctuated as to the relative advantages of the chain pump and the common pump. In 1802, the *Constitution* had two chain pumps installed to supplement the original bucket pumps, but in the course of a few years they were discontinued, partially because of prejudice of the seamen but more particularly because of the labor and expense of repairing the chains and leather discs, between thirty and fifty of these having to be renewed at a time instead of the single piston of the common pump. In the Perkins pump, the only rubbing parts to be releathered were the two triangular valves which formed the bucket.

the vessel which has one of these pumps, discharge the water, in certain cases, by her own motion. If this invention should prove as useful as we trust it will, it certainly will deserve the attention of every ship owner, and the patronage of the proper guardians of our gallant navy.

The great fault of the common ship's pump was that the valves were generally but half the area of the pump barrel and did not open wide enough to allow the water to flow freely. A small chip of wood lodging between the foot valve and its seat rendered the pump useless. On the *Independence, Washington* and also the *Franklin* 74's the Perkins pumps were eight inches square, worked in pairs, two forward and two amidships, and with a full crew manning the ropes, half a ton of water could be raised at each stroke. In addition to these, there were four smaller pumps, five inches square, termed "every day pumps." These were for cleansing between decks and in case of fire. On Plate XI, is reproduced Perkins' account for $360 for pump valves supplied to the *Washington,* which bears the signature of Commodore Isaac Hull,[74] a member of the Naval Board. In a communication in 1816, Commodore Bainbridge expressed his complete approval of Perkins' triangular valve pumps, as follows:

> Having seen one of Mr. J. Perkins' Patent Pumps on board U.S. ship Independence, I do not hesitate from experiments I have made, to declare that its simplicity and efficiency, exceed any pump within my knowledge hithertofor invented, and I do recommend it to be placed in all vessels of the United States Navy. Its great superiority in force with the application of only an equal power compared with the pumps used in our merchants service, which is so easily and fully demonstrated, renders it in my opinion worthy of being adopted in that service, and I recommend it to merchants and others in navigation as an invention eminently conducive to the preservation of ships and cargos.
>
> William Bainbridge.
>
> U.S. Ship Independence, Boston Harbor, January 9, 1816.

Of the many other inventions and devices which Perkins contributed toward improving the safety and convenience in handling ships of war, it will be of interest to read an editorial from the *Boston Gazette,* which was published in July of 1815. The editor stated:

> NAVAL IMPROVEMENTS.
>
> The indefatigable zeal of Com. Bainbridge, in superintending the building and equipment of the Independence, line of battle ship, deserves the highest commendation. To his exertions chiefly, the public are indebted for a great number of nautical improvements, which have been first applied on board this ship. Among them are the pumps, with triangular valve boxes, lately invented by Mr. J. Perkins, of Newburyport—an instrument for ascertaining the ship's trim, called an Orthometer; and a new mode of ventilating, both invented by the same gentleman—the repeating guns, placed in the tops and other parts of the ship—and many improvements in gunnery—in the mode of elevating the piece, the form of the shot, &c. All these promise to become highly advantageous to the naval service.

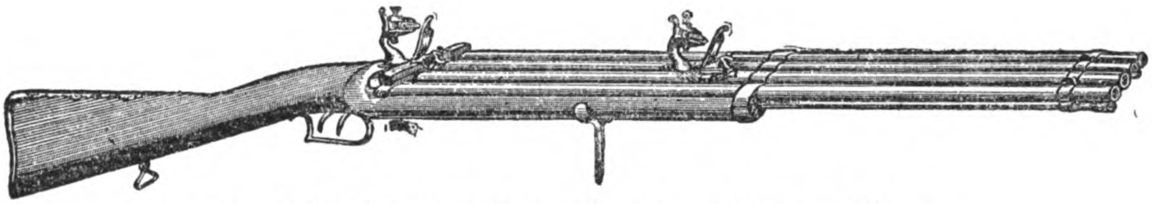
In this comprehensive list of innovations ascribed to the *Independence* several are rather outstanding for naval practice in that day.

The orthometer mentioned, and also the pleometer, which is a companion instrument,

[74] Isaac Hull, born in Derby, Connecticut, on March 9, 1773. He entered the navy in 1798 and was promoted to captain in 1806. Was for a long period a member of the Naval Board and also Commandant of the Boston and Washington Navy Yards. Hull served his country as captain and commodore for 37 years and was considered the ablest sailing captain in the entire fleet, as several of his historic exploits testify. He died in Philadelphia on February 13, 1843.

were for ascertaining the trim of a ship under sail and were fixed in the captain's cabin. The orthometer gave the fore and aft movement of the ship and the pleometer indicated the amount of careen. Both these instruments also showed any shift in the cargo or stores. The construction details of these instruments will be found fully described in Appendix G.

The ventilating of ships' holds at this period [75] and for the next fifty years received but scant attention and Perkins was the first to devise a simple and reliable method of circulating fresh air by utilizing the motion of the ship for this purpose. He employed for this several large square iron tanks divided into compartments into which air pipes were led. Each tank was half filled with water and as the ship pitched and rolled, this water washed back and forth, forcing the confined air out through the air ducts into every part of the hold. An engraving of this apparatus will also be found in Appendix G.



A French Naval Repeating Gun from Bannerman's Catalogue of Weapons.

Perkins' improvements to the gunnery of his day might have been more far-reaching if the occasion of war had occurred to prove and record their worth. The term "repeating guns" applied to firearms at this period (firearms which had not advanced as yet beyond the flintlock) could imply but little more than a carbine with several barrels which were discharged either single shot or as a volley similar to those used on Admiral Nelson's ships at the Battle of Trafalgar in 1805. The French used muskets with revolving chambers at an early period as well as grouped barrels which could be fired separately.[76] That the

[75] Up until the time of the first appropriations, in 1839, for building steam vessels for the navy, warships under sail were provided with a negligible amount of mechanical aids and the least possible comfort for the men. Though applied mechanics predominated everywhere in a sailing ship, such applications were to make things possible rather than to increase the efficiency of the vessel and its crew. Gun carriages were little more than barrows on wooden wheels, hauled in and out of the gun ports by rope tackles. The guns were elevated by hand spikes thrust under the breech and supported when fired by a quoin, a simple wedge of wood. Gun sights, if any close shooting was required, were made by the ship's carpenter from a wooden batten, grooved and lashed along the gun with marlin. The pumps were of the simplest construction, made from a bored tree with long levers to accommodate a dozen men. Though chain pumps with iron and leather discs were early employed on warships, more often than not they were made with balls of wood or knotted rags spaced along the links of the chain. These primitive hydraulic machines often broke or choked up at the most critical times during the stress of battle or storm, making the possibility of foundering almost a certainty. The simple instruments then in use to aid navigation had advanced little beyond those known to Columbus and were for course finding only. Of ventilation in these early warships, there was none except when fine weather permitted open ports and unbattened hatches. The officers and seamen had their quarters between decks in semi-darkness, down many ladders, redolent of the foul water of the bilges. This moist, dead air permeated the stores and the spare gear and caused timbers to rot from within, long before the exterior of the hull became unseaworthy. Yet up to this time, nothing had been achieved or even considered to overcome these disabilities. When this picture of the navy under sail is remembered, then Perkins' scientific and mechanical contributions to the betterment of conditions in the American Navy must be accounted of considerable importance.

[76] In the 1931 catalogue of weapons of their military museum, issued by Francis Bannerman and Sons of New York, is shown several types of ancient flintlock repeating and volley guns. The Nelson naval gun shown has seven barrels fired simultaneously by one lock. Another illustrated has a single barrel and four powder chambers, each with its individual pan, to be fired in rotation by a flintlock. There is also shown a French

repeating guns on the *Independence* were placed "in the tops and other parts of the ship" seems to indicate they were more or less permanent and fixed on swivels.

In the midst of all his other work, both private and public, Perkins still found time in the early part of 1815 to design a central heating plant for the Massachusetts Medical College in Boston and to superintend its installation. This method of heating, now almost universal, was at this period exceedingly novel. The Massachusetts Medical College was located on Old Marlborough Street from the date of its founding in 1810 until 1816. In 1814 the state made a substantial grant to the school and a new building was erected on Mason Street near Boston Common and the Mall. This building was of brick, eighty-eight feet long and forty-three feet wide at its widest part, which supported a handsome octagonal dome. Located on the first floor of the new building were a chemical lecture room, a medical lecture auditorium and a chemical laboratory. On the second floor was the anatomical theater with semicircular seats for the students. Opening off this were the museum room and a medical library which contained between three and four thousand books. Charles Shaw, a contemporary writer in 1817, stated that:[77]

> The whole building is warmed by a single stove situated in the cellar, calculated by the inventor Jacob Perkins for burning the Rhode-Island coal. Owing to the smallness of its draught it burns this coal in great perfection heating up a permanent and intense heat. The Stove is surrounded by a brick chamber from which a brick flue is carried up to the second storey, communicating by large pipes or aperatures with all the principal rooms of the house. The air is admitted from the outside of the building, through a brick passage way down to the stove; a portion of it goes to maintain the combustion; the rest being rarified by the heat of the stove, ascends rapidly through the flue, and may be delivered at pleasure, into any or all the apartments, by opening the pipes or communications. The strong current of heated air thus obtained is sufficient to warm the largest room in a very short space of time.

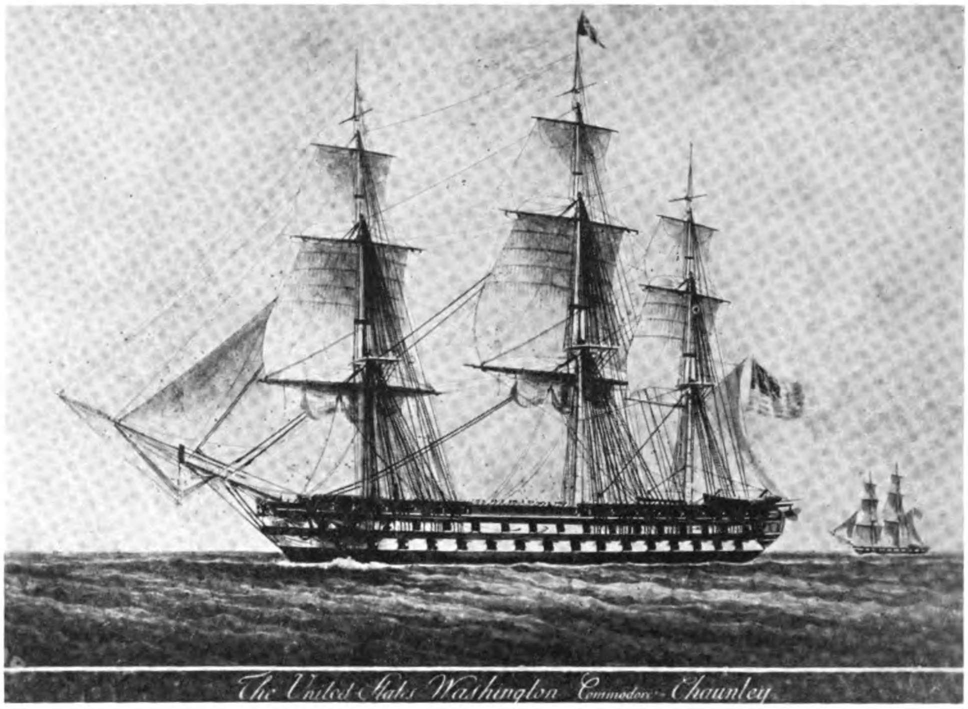
Perkins is said to have perfected this system of warming buildings in 1810,[78] but this is the first instance of the method being used on so large a scale. Apparently Perkins received no payment either for the use of his idea or the installation of the heating system and he did not patent this useful invention in America though later in England he did obtain a patent on this form of heating, using in this instance a portable self-contained stove. A contemporary picture of the Massachusetts Medical College is shown on page 55.

With the close of the war and the inevitable chaos which followed the advent of peace, Perkins' work in Boston came to a close. He seemed to have then definitely decided to come to Philadelphia and take up some active part in the firm of Murray, Draper and Fairman. His decision to make this move coincided with the Government's plan for establishing the Second United States Bank, one branch of which was to be located in Philadelphia. The engraving plant on Fruit Street, Newburyport, was still being conducted by his brother Abraham, who had brought to this enterprise a staid and hardheaded business ability which was in direct contrast to the brilliant but erratic mind of Perkins himself. Mechanical ideas, inventions and improvements sprang from Jacob Perkins' brain like

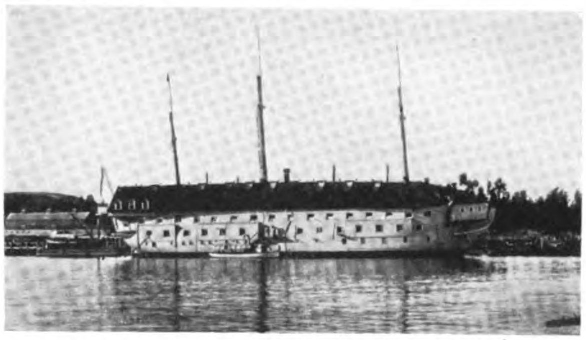
flintlock mitrailleuse with four barrels placed side by side and two locks to fire the barrels singly or in pairs. A socket and swivel form a part of this gun which suggests that it was intended to be used on some predetermined part of a ship or rampart. That the *Independence* repeating guns approximated in principle and in design one of the foregoing weapons seems most probable.

[77] *Topographical and Historical Description of Boston:* Charles Shaw, 1817.

[78] Currier states that Perkins invented this form of central heating in 1810 at Newburyport, but does not give the circumstances.



United States Ship of the Line *Washington*, 74 Guns. Built at Portsmouth, New Hampshire, in 1816. From a water color by Francois Roux, 1829, in the collection of Phillipe Keller, Paris. *Reproduced by courtesy of the* Naval Records Library, Washington.



The Old *Independence* as a Receiving Ship at Mare Island Navy Yard in 1856. *From a photograph in the library of the* Mariners' Museum, Newport News.

Commodore William Bainbridge. *From a painting by* John Wesley Jarvis.

golden wheat growing in a sunny field but of the harvest he gave but little thought. Others too often reaped while Perkins traveled on to pastures new, generally only pausing long enough to garner sufficient to further his newer projects.

But before leaving Massachusetts, Perkins had perfected and patented yet another nail machine. This was the "cylindrical nail cutter" of January 16, 1815. On November 1st of the same year, which was about the time he finally left Newburyport to join his partners in Philadelphia, Perkins took out a supplementary patent for some further improvements to this machine.[79] In the absence of any existing specifications, it is mere conjecture as to the method used for making nails by circular motion except that the nails were sheared one after the other from the iron strip by a series of cutting blades spaced diagonally on the rim of a wheel or roller which revolved in close contact with a fixed cutter.

Perkins' most prolific year of creative endeavor was 1813, during which time he filed patents for no less than seven inventions and improvements. One of these patents, dated March 23rd, was a machine for making screw shanks, rivets, etc., from lengths of iron, copper or brass rod. As a part of this patent, Perkins included his improved safety lock for bank vaults. This lock is described by Perkins as of "a peculiar construction," and he goes on to say[80] "these locks are so constructed that no person can unlock them without being informed of the secret word or key for the arrangement of the rings, though all apparatus may be put into his hands, and he may even see the operation performed; this has been proved by repeated experiments." From this description it is apparent that Perkins' lock was of the type known as a "letter padlock" in which there is a string of discs, each with a number of letters arranged around their rims. These discs are turned until the secret word is spelled out; when this is done the jaws of the padlock can be pulled apart. This is a very old form of keyless lock, said to be a Dutch invention of the 17th century. An early play by Beaumont and Fletcher in 1615, *The Noble Gentleman*, has these lines:

> A cap-case for your linen and your plate,
> With a strange lock that opens with A. M. E. N.

and again in 1620 Thomas Crew writes:

> As doeth a lock that goes
> With letters; for, till every one be known,
> The lock's as fast as though you had found none.

Letterlocks appear to have been first used on couriers' dispatch boxes in 1650. The modern development of this device is the dial keyless lock used now on all bank vault doors. In Perkins' day, the safes used by bankers and business houses were of very flimsy construction, consisting of little more than a large upstanding box made of riveted sheet iron. Some effort was made to render these early safes fireproof by interposing slabs of soapstone between the inner and outer casings. The doors were swung on long external hinges and the

---

[79] This was the last of Perkins' nail-making patents. By now there were numerous other inventors and the manufacture of machine made nails had become an enormous industry. Albert Gallatin, some years before when Secretary of the Treasury, in a report to Congress in 1810 stated that "two thirds of the whole quantity of iron flattened by machinery in the United States was used in the manufacture of cut nails."

[80] *Newburyport Herald*, August 18, 1815.

locks, of which there were generally two, were closed by a complicated key cut with intricate wards. All of which was good enough if an attempt were made to open the safe by a trial of keys of similar type but useless when pitted against a clever picklock armed with a few pieces of bent wire. Perkins without doubt found a ready market for his patent padlocks as they could be so easily fitted to the existing safe doors with addition only of two strong eye bolts. One of these patent locks was used in the Mechanics Bank in Philadelphia in 1814[81] and was on view to all "interested and responsible citizens," according to a local advertisement. Perkins appointed agents in various cities to introduce his locks to banks and merchants. In Philadelphia his representative was Dr. Thomas P. Jones,[82] who at this time was Perkins' agent for the backwater mill patent. Dr. Jones, a few years later, also became one of Perkins' many transient partners in a somewhat more ambitious business venture.

In 1816 a company of Massachusetts merchants, by special act of legislature, formed a stock company to exploit the triangular valve pump, under the title of "The Patent Pump Company." The chief director of the concern was Francis C. Lowell,[83] of Boston, to whom Perkins had assigned the pump patent for a lump sum of money the previous year. Lowell and his associates afterward had much to contend with owing to the apparent infringements of this patent; and a test case, tried in Boston in 1817 between Lowell and Winslow Lewis, was decided against the pump company. Winslow Lewis at this time was the owner of a somewhat similar pump patented by James Baker in 1817, it had butterfly valves and was of a different shape, being round instead of square. A brief of this case is considered of sufficient interest to be given in Appendix E, as an example of patent law jurisprudence of this period.

Perkins had planned to come to Philadelphia early in December of 1815, leaving his family in Newburyport until such time as the success of the proposed Second National Bank was assured.

Perkins' family at this period consisted of his two sons, Ebenezer Greenleaf and Angier March, both under twenty, and four daughters, who were Sarah Ann, born in 1793, and who had recently married Mr. Joshua Butters Bacon of Boston; Louisa Jane, born in

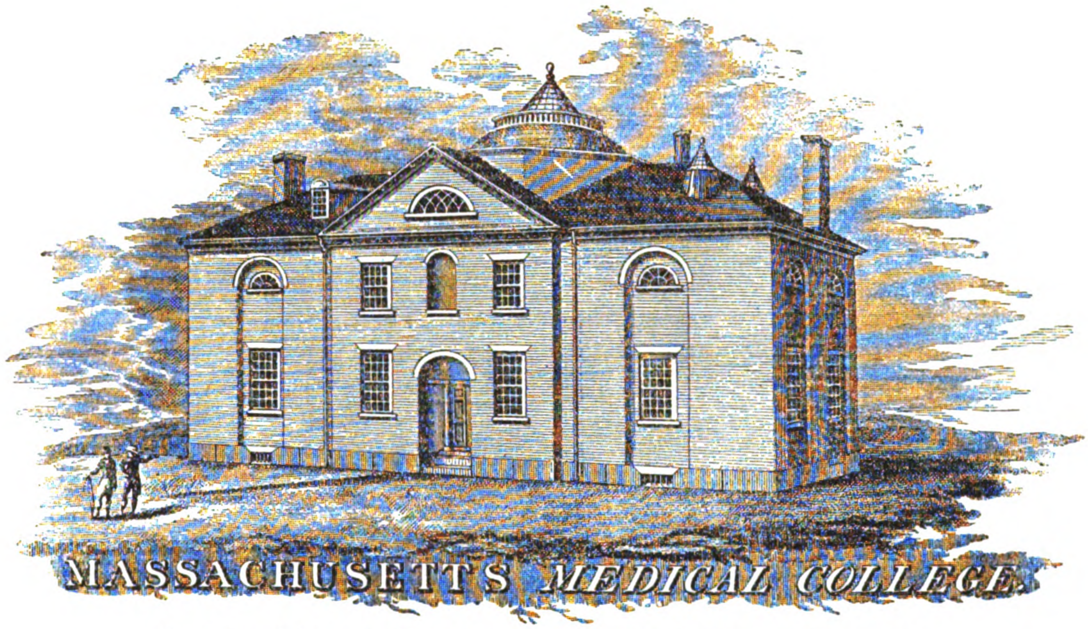
---

[81] The Mechanics Bank was located in 1814 at No. 9 South Third Street. It commenced business on January 20, 1810, with a capital of $700,000. On May 16, 1841, it closed its doors through its inability to pay in specie as demanded by the state of Pennsylvania under the Act of May 1, 1841.

[82] Dr. Thomas P. Jones was born in Herefordshire, England, in 1774. Practically nothing is known about his early life except that he lived in Newbern, North Carolina before settling in Philadelphia. He probably came to Philadelphia to engage in teaching natural philosophy and physics and it is likely that he welcomed a business association with Perkins as by acting as agent for Perkins' inventions, he was able to eke out the slender remuneration derived from teaching. In 1825 Dr. Jones was appointed professor of mechanics and natural philosophy in the newly founded Franklin Institute in Philadelphia. At the same time he was also placed in charge of the *Franklin Journal* as its first editor. In 1828 he received the appointment of Superintendent of Patents at the United States Patent Office and thereupon removed to Washington but he continued his affiliations with the *Franklin Journal*. Dr. Jones held this appointment at the Patent Office until 1829, after which he was transferred to the Department of State when, in 1836, he was appointed Examiner in the Patent Office until his resignation in 1838, continuing thereafter his editorship of the *Franklin Journal* until his death in Washington on March 11, 1848. It was through the loyal friendship of Dr. Jones that so much of Perkins' work with high pressure steam in England was recorded in the pages of the *Journal*.

[83] Francis C. Lowell was one of the leading manufacturers of cotton goods in Massachusetts. In 1812, being unable to obtain a satisfactory loom in Europe for spinning, he set himself to design a suitable machine and with the assistance of Paul Moody of Amesbury, the first successful all-American power loom was built and patented in 1815. Lowell's first association with Perkins was in connection with water power to work his mills. The acquisition of the pump patent appears to have been merely as a speculative business enterprise.

1801, Elizabeth, born in 1804, and Henrietta born in 1806. Three of his daughters had already died young. These were Jane, in 1801, and his youngest child Mary, who was born in 1809 and who had lived only a little over a year. His eldest daughter, Hannah Greenleaf, born in 1792, had died in 1813 of the plague on the eve of her marriage to Dr. Johnson of Newburyport.



Reproduced from the *New England Journal of Medicine and Surgery*, for April, 1816. The scene of Jacob Perkins' central heating installation.

PHILADELPHIA

1815-1819

PERKINS seems to have arrived in Philadelphia about December 3, 1815, and he went at once to the home of Gideon Fairman, who then was living on the southwest corner of Chestnut and Seventh Streets, where he apparently lodged during the three years of his stay in the city. Accompanying Perkins was his eldest son, Ebenezer Greenleaf, who was to assist him in the projected work. Ebenezer's health seems to have been always poor and he never appears to have made any mark for himself in the business world and his name is seldom mentioned in connection with that of his famous father's. Perkins' name does not appear in the Philadelphia City directory at any time and it may be inferred from this that he neither owned nor rented a home during his stay in Philadelphia.

The establishment of the Second National Bank of the United States now seemed assured. Perkins, who had so much at stake in this eventuality, decided to make a brief visit to Washington to see his friend, Jeremiah Nelson, who as representative in Congress from Massachusetts, was in strong favor of the measure. Through some mischance, Perkins did not see Nelson either in Washington or in Philadelphia as he had hoped and the following letter was sent to Nelson in Boston: [84]

Phila 5 December 1815

Jeremiah Nelson, Esq.
My dear Sir:

I am extremely sorry that I was not so fortunate as to see you when you passed through this city— It would have given me much pleasure to have conversed with you a few minutes— I was at Washington about 20 days since and saw Mr. Dallas— He thinks there will be a National Bank— In case there is he will use my paper, a sheet of which I send you, which I would thank you to shew the members— I saw this day Comdr. Decatur he informed me the different Instruments, as well as the pumps that were fixed on board the Mediterranean Squadron, answered every purpose expected. The Bathometer he means to recommend to the Government to purchase the right and keep it a secret as it is found of essential utility especially in rough weather.

I have endorsed a line to Comodor Rogers I would thank you to forward it and get the draft on the Navy agent Benton, and enclose it to your friend.

Yr. ob set.
Jacob Perkins.

As soon as the Bank bill moves you would do me a favor by informing what impression it makes.

In this letter Perkins brings up with justifiable enthusiasm the subject of his equipment and instruments which had been installed in the naval vessels which had recently returned from the Mediterranean under the joint commands of Commodore William Bainbridge

[84] Simon Gratz Collection, in The Historical Society of Pennsylvania.

and Commodore Stephen Decatur.[85] These instruments, the orthometer and the pleometer and also another device termed the bathometer used for deep sea sounding, seem to have been put to a practical test by the squadrons during the long cruise and had met with the wholehearted approval of the two commanders.

The last lines of Perkins' letter are pregnant with suspense and anticipation. His note to Commodore Rodgers[86] was in all probability a respectful reminder for the payment of his account due on the nautical instruments supplied to the fleet, for at this time it is evident that Perkins needed all the funds he could command. Obviously the political pressure to swing the new Bank Bill at this time was tremendous and Perkins with much to gain and a great deal to lose contributed his own modest share financially toward the inevitable lobbying and wirepulling.

Though the Second National Bank of the United States did not go into operation until 1817, some account of its inception and organization may be of interest here because of its eventual influence upon Perkins' business affairs in Philadelphia.

Early in 1814 members of Congress for the state of New York presented a petition for the establishment of a national bank with a capital of $30,000,000 but a Committee of the House reported unfavorably on this as being unconstitutional. Various suggestions for a national bank were brought forward and in October of 1814 Alexander James Dallas, the secretary of the Treasury, submitted a report strongly favoring a national bank.[87] He considered such an institution "the only efficient remedy for the disordered condition of our circulatory medium." Various bills were introduced at this time as to how the money was to be subscribed and as to the obligations of the proposed bank to pay in coin or paper, more especially under the exigencies of war. Dallas finally pronounced the measure as proposed inadequate and it was vetoed by President Madison on January 30, 1815.

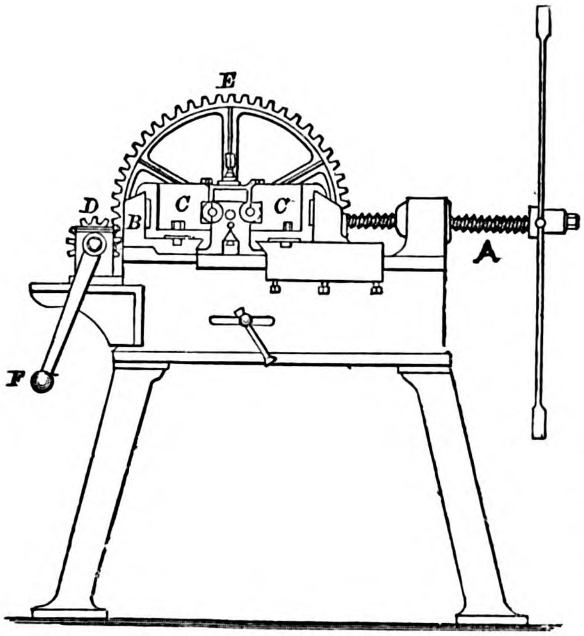
Upon the opening of Congress on December 5, 1815, Madison gave special reference to the bank in his seventh annual message and Dallas in his report for the year 1815 again urged the establishment of a national bank. After much discussion, the Bank Bill passed the House on March 14, 1816, and the Senate in April and was approved by President Madison shortly thereafter, on April 10th. The capital of the second United States Bank was $35,000,000, with its main office in the District of Columbia and branches were to be opened in any state or city where not less than 2000 shares were held. Each share was valued at $100. The bank opened officially on January 17, 1817, with eighteen branches

---

[85] Stephen Decatur, born in Sinnepuxent, Maryland, on January 5, 1779. He entered the navy as a midshipman in 1798. Commodore Decatur was killed in a duel by James Barron, another naval officer, on March 22, 1820. On March 2, 1815, the United States having declared war on Algiers for that country's piratical practices, two squadrons were dispatched to subdue the Dey. Commodore Decatur was the first to leave, from New York, with his ships and a month or so later Commodore Bainbridge sailed with another squadron from Boston. A list of Bainbridge's ships taken from the *Boston Gazette* of November 24, 1815, gives the following vessels: *Independence*, ship of the line, and two frigates of the second class *Macedonian* and *Congress*, also the brigs *Chippewa*, *Flambeau*, *Fire Fly*, *Boxer* and *Enterprise* and several small schooners. It is impossible now to say on which ships Perkins' instruments and pumps were installed (the *Independence* excepted) but it may be assumed that they were applied on several of the frigates and brigs of both squadrons.

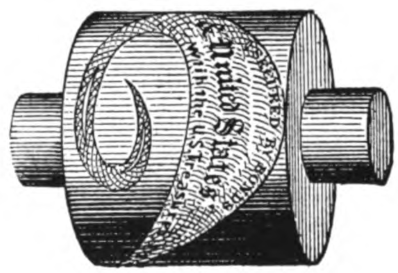
[86] John Rodgers, born 1771, died 1838. He entered the navy as a lieutenant in 1798 and was promoted to captain in 1799. From April, 1815, to December, 1824, Commodore Rodgers served as President of the Board of Naval Commissioners.

[87] At the expiration of the First Bank of the United States, in 1811, state banks greatly increased in numbers, 120 being chartered between 1811 and 1814. The needs of war and the suspension of specie payments in 1814 caused even the Government to accept state bank notes in payment of all public dues.

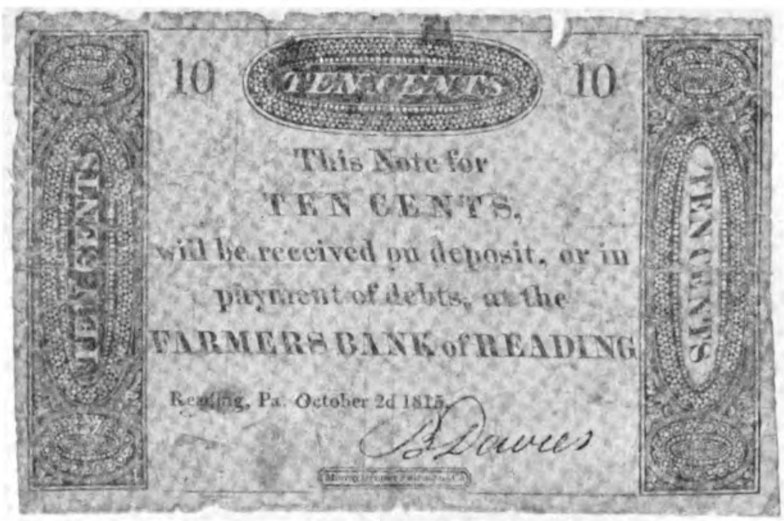


Perkins' Transfer Press.

The Roller Press for transferring the matrix to the roller die and the roller die to the copper or steel plate. A is the screw to compress the roller and plate between the frame B. The large gear wheel E with a plain roller imparts the motion to the plate and the handle and pinion F D provide the power.



A Hardened Steel Roller Die. Similar dies were used in the process of water marking paper and calico printing.



A Bank Note for Ten Cents, engraved by Murray, Draper, Fairman and Co. Dated October 2, 1815. *In the possession of the authors.*

but the management was too easygoing and too anxious to do business, so that by 1818 the bank was compelled to import specie from abroad to back their enormous printed currency which stood, in 1816, at $110,000,000 in notes and much more than this figure by 1817.[88] It is not proposed to go further here into the history of the Second United States Bank, but enough has been sketched to show the reason for Perkins' deep interest in the matter of the possibilities of engraving and printing for this institution.

By the summer of 1816 by unremitting effort and influential support, coupled with perhaps the finest system of bank note engraving that had ever been evolved, Perkins succeeded in having his siderographic plates accepted by the Federal Government for printing all the notes of the new national bank. This fact was announced in an editorial in the *Aurora* of June 7, 1816:

> We learn that the steel dies of Mr. Perkins, are to be put in requisition by the national government, for impressing their new emission of bills. The admirable invention of this great mechanical genius, is the only one we believe, that has triumphed over the arts of a whole host of counterfeiters.

This artistic and business triumph should have proved of great material advantage to Perkins, but the bank's mismanagement and rapidly accumulating financial difficulties nullified any permanent gain for him in this direction.

The national bank encountered many oppositions from its very inception. The state banks were alarmed and hated the thought of a powerful rival. Their dividends would be cut and many would have to close, it was feared. Memorials and petitions against the bank flew in all directions. So little actual coin was in circulation through the country at this time that local banks were even issuing bearer notes for as little as two cents to provide change.[89]

The same year that Perkins went to reside in England, the cornerstone was laid on April 19, 1819, for a classical stone building to accommodate the United States Bank. Designed by William Strickland it was opened for business in 1824 and was thus used until 1845. When the national bank finally closed in that year, the building was occupied until recently as the Custom House.

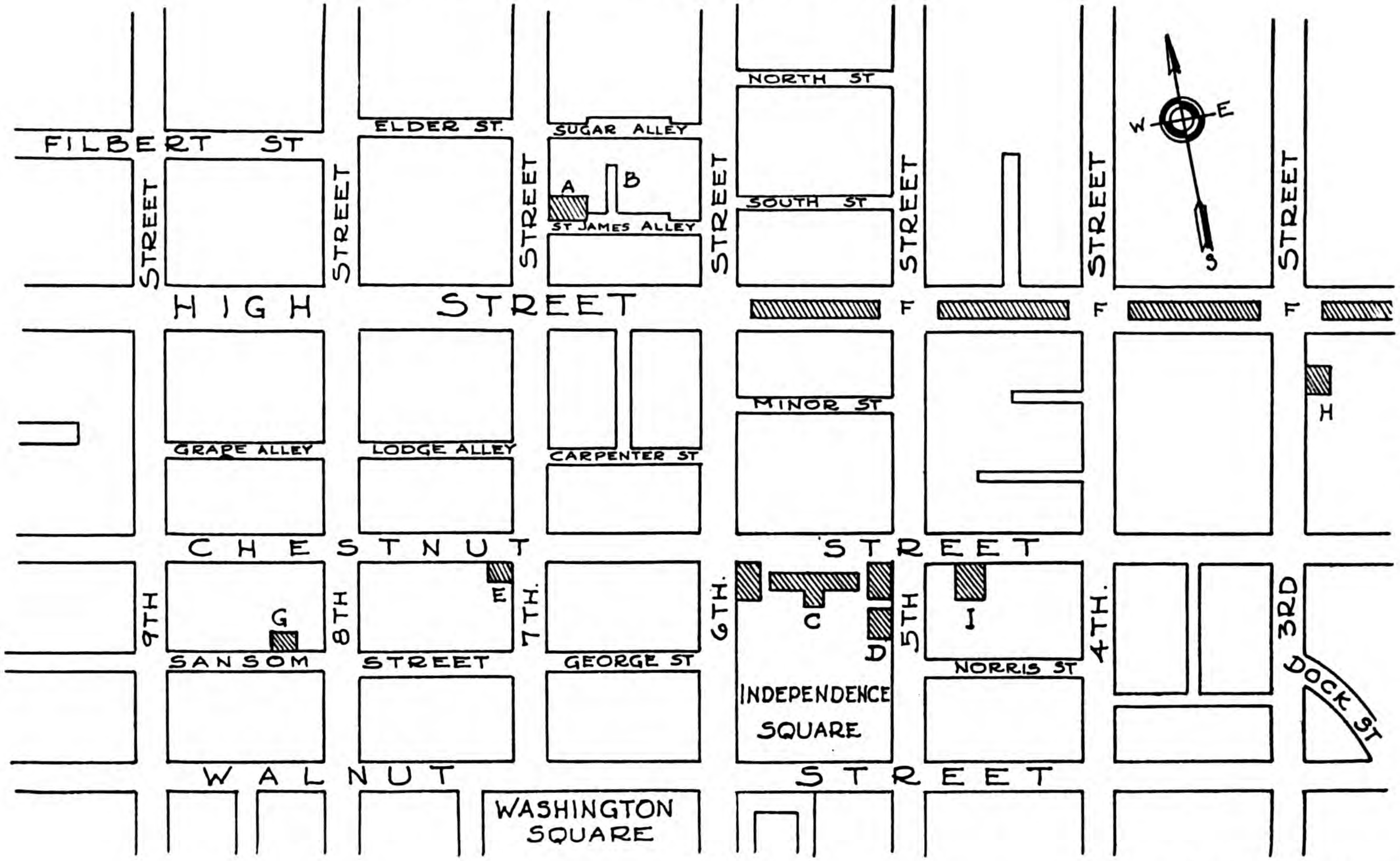
The engraving plant of Murray, Draper and Fairman was located in 1816 at 47 Sansom Street. See Map 5. And here on the premises lived John Draper, the second partner. George Murray at this time lived a few doors south at No. 45. The business premises of the firm was of the regular dwelling house type, general in the city. The houses were built by William Sansom in 1798 and they all adjoined in a stiff row, narrow and having three stories. The die making and printing plant usually employed three or four workmen to carry out the mechanical end of the engraving process. Little if any bank note engraving and printing was done by Murray, Draper and Fairman before 1811 but in March of that year they purchased all the dies, tools and machinery for bank note making from Abel Brewster of Philadelphia for the sum of $7,500. Thereafter this line of business was conducted as an addition to the illustrating and pictorial engraving which had previously

88 The foregoing has been compiled principally from *Documentary History of the Bank of the United States*, by M. St. Clair Clarke and D. A. Hall, Washington, 1832.

89 The Second Bank of the United States, 1816, was chartered for a period of twenty years with branches in Philadelphia, Washington and other cities. The bank's financial standing declined from the start and in three years was in a state of almost bankruptcy, due to a general public recklessness in land speculation and a lack of proper security for bank loans. A trial was made of issuing coin in 1816 but these disappeared at once by reason of hoarding and small change had to be made almost entirely by paper notes.

MAP 5

THE BUSINESS CENTER OF PHILADELPHIA
AS JACOB PERKINS KNEW IT 1815 - 1819



Drawing by the Authors.

A—St. James Church. B—Location of the Fire Engine Manufactory. C—Independence Hall.
D—The American Philosophical Society. E—Gideon Fairman's Home. F—City Markets.
G—The Engraving Plant of Murray, Draper, Fairman and Co. H—The Mechanics Bank. I—Site of the United States Bank.

formed the major part of their work. After the sealing of the joint patents between Perkins and Murray in 1813 for the transfer machine and printing press, bank note engraving was found to be the most profitable kind of work ever done by the firm.

On December 18, 1816, Perkins in partnership with Thomas Gilpin, a paper manufacturer, took out a patent for impressing watermarks, the principle of which was to engrave a plate bearing the device and then transfer it to a roller which left an impression in the wet paper. Thomas Gilpin was an industrialist of varied business interests, who during the War of 1812 had erected several extensive cotton and woolen mills along Brandywine Creek near Wilmington, Delaware. He had then turned his attention to paper making and had invented a cylinder machine for this purpose, the first ever to be used in this country, which made paper in a continuous sheet. This machine was patented in December of 1816. Two years later, with subsequent improvements, sheets one thousand feet long and twenty-seven inches wide were made for writing paper. By using Perkins' engraved rollers, a watermark was impressed on each component section of this continuous paper strip.

Perkins' first months in Philadelphia must have been to him of steadily increasing interest. At the time of his first brief stay in the city in 1792, he had come as a young man of twenty-six to apply for some kind of position in the new Federal Mint and in this had failed. Now in 1816, almost twenty-five years later, he returned as a mature man of fifty years, welcomed and recognized as a person of acknowledged standing and ability. It is not known just how often Perkins had visited Philadelphia during the intervening years, except for the one recorded in 1813. But it may be surmised that he was already acquainted with many of the city's foremost artists, scientists and industrialists. At this period Philadelphia was already a comfortable and substantial city. It had outgrown its purely political importance and since 1800 was turning more and more to the development of manufactures. By then the city wharves extended nearly two miles along the Delaware River and interspersed among the sailing craft, there now plied upon its waters the first passenger boats to be propelled by steam power. Of the solid and material comforts of Philadelphia, a contemporary of that day wrote: [90] "The wharves are built of square casements of logs, filled in with earth and stone. The city is lighted by 1132 lamps, enclosed in glass lantherns, fixed on the tops of posts placed on the edges of the footway. The lamps under the market houses are lighted every evening at dusk, and continue burning until daylight. The other lamps are lighted only on those nights when the moon does not give sufficient light. The improved parts of the city are paved with round stones brought from the bed of the river at Trenton Falls. The foot-ways are paved with brick, and raised on a level with the highest part of the street and defended from the approach of carriages by ranges of curb stones. The houses are from two to four stories high, and are built of brick, the superiority of which is well known through out the United States. In general, the houses are covered with cedar shingles but slate is rapidly coming into use. The flights of steps and the cellar doors protruding into the pavement, and diminishing its breadth, are striking errors. The front walls of the houses are fourteen inches thick, and the internal walls nine inches. The edges of the pavements are planted in many streets with Lombardy Poplars, for the introduction of which we are endebted to William Hamilton, Esq., who brought them from England about the year 1784." This, then, was Philadelphia as Perkins found it in 1816.

Perkins does not appear to have had any particular interest in the steam engine before

[90] *The Picture of Philadelphia*, by James Mease, M.D., Philadelphia, 1811.

he came to live in Philadelphia. All his previous work in the field of invention had so far not touched upon any problems of thermodynamics as exemplified by steam. The application of this power was practically unused in America up to 1805, but nevertheless, theoretically it was well understood and taught by scientific men of Perkins' day. At this time very few steam engines were in actual use; manufacturing, though great enough in the aggregate, was not conducted on a large scale by individual firms and water power was so plentiful that manufacturers, those at least up to 1800, had made it an axiom to locate on a good stream of water where power from this source could be had almost without cost and there they remained, or as occasion demanded, sold or handed on their mills to others, who carried on in the same location and in the same manner. Thus there seemed little inducement or even necessity to power the mills in rural districts by any other means than water, for at this early day the water driven mill could far outmatch the steam engine for almost every manufacturing requirement.

It was only when factories which had been established in growing cities were finally faced with the necessity of some form of adequate power to supplement hand labor that steam was seriously considered. The steam engine for propelling vessels was a delayed application in Europe, principally due to the type of engine which was available for this purpose, but with the advent of higher steam pressures and lighter machinery, the use of steamboats in America had rapidly forged ahead and this form of transport had by now reached a point of reliability, if not of safety, that was becoming increasingly popular with the public. This new world of steam power in Philadelphia, which had so recently opened up before Perkins, must have made a profound impression, for with his natural grasp of all things mechanical, the soaring possibilities for improvements seemed illimitable.

It was, therefore, quite natural that one of the first men with whom Perkins made contact with in Philadelphia was Oliver Evans,[91] then in his sixty-first year and at that period the greatest practical exponent of the high pressure steam engine in America. Evans and his family were living when Perkins knew him in a large and comfortable home at No. 353 Sassafras Street, on the southeast corner of Tenth Street. Evans had by now arrived at the zenith of his professional prosperity, but the long years of arduous work and business care had by then undermined his health to such an extent that he was to live but three years longer. There can be no doubt that a deep and genuine friendship sprang up between these two men, whose characters were so dissimilar and yet whose purposes were so alike. One can picture their long and stimulating conversations on mechanics and science but more especially upon the problems of steam, at the home of Evans where Perkins would have been a welcome guest. These meetings and mutual exchange of ideas undoubtedly influenced the whole of Perkins' future field of endeavor. This is amply borne out by a statement made years later by Perkins in his book *The Concentrating Steam Engine*,[92] which he published in London in 1824. In this he says:

---

[91] Oliver Evans, born in Newport, Delaware, on September 13, 1755, died in New York on April 15, 1819. See *Oliver Evans: A Chronicle of Early American Engineering*, by Greville Bathe and Dorothy Bathe, Philadelphia, 1935, for further details of his life and work.

[92] *An Account of the Concentrating Steam Engine, by the inventor Jacob Perkins.* Perkins evidently published this book as the easiest way to place before the public the full details of his sensational discovery. This work is now extremely rare, the authors only having found one copy in the United States which is in the Library of the Franklin Institute, Philadelphia, and is not complete as the plates, presumably of the engine and generator, are missing. At the Patent Office Library in London, it was learned that a complete copy of this book was once in their library but it had been missing for many years and that another copy to replace it could not be found.

Perkins' Association with Oliver Evans

PHILADELPHIA
1815-1819

> Having many years since witnessed some facts relative to steam of high expansive force, which was made use of by that extraordinary genius the late Oliver Evans, to work his high pressure engine, I was satisfied that, to make use of steam simply as an agent for forming a vacuum for the purpose of using atmospheric pressure, was taking all the advantage which that extraordinary power possessed. Conversing with Mr. Evans frequently upon his many useful inventions, more particularly his steam-engine, gave me an opportunity of seeing what has since led me to a series of experiments, which will, I have no doubt, occupy a large portion of the remaining part of my life. Although I was satisfied that his stride was quite equal to that of the truly celebrated Watt, yet I believed much more was left to be done; but as I considered the invention wholly in his hands, it would have been unfair to attempt to improve upon it, as long as so able an engineer was directing his time and talents to that object.

Perkins, in the midst of his own professional work at the engraving plant, managed to follow up with avidity his newly found interest in the steam engine and made frequent visits to the Mars Works, Evans' engineering manufactory at Ninth Street and Ridge Road. There he watched the progress of the steam engine and boilers then being constructed for the United States Mint on Seventh Street. Perkins was also introduced to Evans' partners, James Rush and David Muhlenberg at the Bush Hill Works where at this time a large high-pressure engine designed by Evans was being completed for the steamboat *Pennsylvania,* which was a sister ship to the *Aetna* then in service on the Delaware River.

In March of 1817 Oliver Evans, wishing to have the testimony of two independent engineers as to the efficiency of his steam pumping engine at the City Water Works at Fairmount, appointed George Clymer, the inventor of the Columbian printing press, and Jacob Perkins to carry out the required tests to prove the actual amount of water pumped into the reservoir in twenty-four hours. The results obtained from these tests were signed by Clymer and Perkins and were published in the *Aurora* on April 1, 1817.

In June of this year Oliver Evans went west to Pittsburgh on one of his frequent business trips connected with his subsidiary engineering establishment there which was under the management of his eldest son George. On this trip Perkins accompanied Evans, probably partially for the pleasant association but more for its business possibilities, as Perkins was anxious to contact some of the nail making establishments in Pittsburgh with a view to introducing to their notice his circular nail cutting machine. The principal nail factory in Pittsburgh at this time was owned by Christopher Cowen and was located at the corner of Penn Street and Cecil Alley. It had been founded as a rolling and nail rod mill in 1812. The census record of 1808 stated that there were four nail factories in the city in that year but to what extent they employed machinery is not known.

While in Pittsburgh, Perkins seemed to have made considerable investigation on the probable causes of boiler explosions. Two recent examples, both with fatal results, were then the chief topic of conversation in the city. These were the *Constitution* and the *Washington,* both of which were passenger and freight steamboats plying between Pittsburgh and New Orleans. On Perkins' return to Philadelphia, he was asked by Roberts Vaux, chairman of the committee then investigating into the causes of steamboat disasters, to submit a report on his recent observations on this subject. Perkins wrote as follows: [93]

> As far as the knowledge of the undersigned extends, all explosions that have taken place, where the engines have been worked at seven pounds and below, have done no injury to the passengers.

[93] From the *Aurora* of July, 1817.

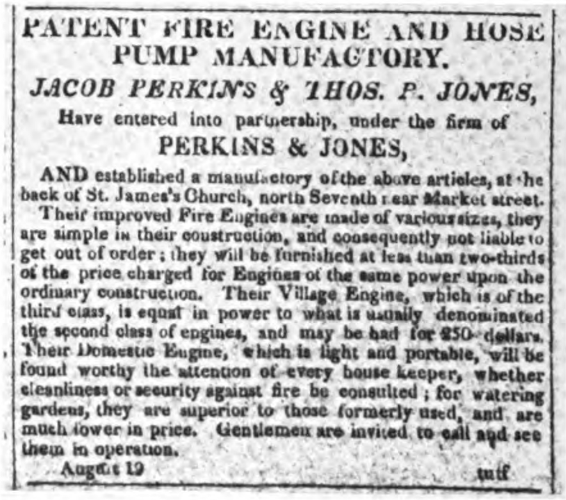
It is the boilers that have been made to bear a higher pressure than seven pounds to the inch, which have proved so fatal; but had the owners known their strength, and been provided with safety valves properly adjusted, no explosions would have taken place, unless they had been constructed like the two on the Mississippi, which have produced such disastrous consequences. This form of boiler should certainly be abandoned; no safety valve nor any precaution would make them secure. These boilers are cylindrical, and have flues passing through their centres. The misfortune has not happened by the bursting of the boilers; but has been occasioned by the flue, where the fire is built, being heated to such a degree, when the water has been suffered to get too low, as to collapse and make an opening for the steam and water to rush out. This was the case with the Washington and Constitution. At the Pittsburgh nail factory, where Evans's most improved boilers had been used for a number of years, it was apprehended it was time to replace them, and while new boilers were making, one exploded while the steam was at sixty pounds. When examined, it was found that a piece was blown out at the top, about four by six inches. It removed a few bricks, but occasioned no mischief. It was found that the thickness of the iron was reduced by corrosion to less than one sixteenth of an inch, (when new it was five sixteenths) at the spot where the explosion took place. The undersigned has not been informed particularly, as to the other disastrous explosions, but he believes, several have taken place as low as twelve or fifteen pounds pressure, and that such ought to be considered as high pressure engines.

Yours, respectfully,

Jacob Perkins.

Roberts Vaux, Esq.
Chairman of the Select Committee of
Councils on the subject of Steam Boats.

These pleasant interludes of sightseeing and travel did much to increase Perkins' stock of general knowledge and to widen his field of practical mechanics, but for a man of considerable family responsibility, they did little toward maintaining his income. Perkins' lack of steady application to any definite line of work over any lengthy period mitigated his chances of ever catching up with his expenditures. In this there was no particular thought nor desire on his part to shirk his obligations but to Perkins it was always the present and the future and he trusted that the past would take care of itself. Perkins' last years in Newburyport had been ones of heavy expenditures. Between 1810 and 1815 no less than twelve inventions had been developed and patents on these obtained, and of this number perhaps only one had yielded any direct gain to the inventor. This one was the triangular valve pump which Perkins had sold to the Lowell Company. Some revenue had certainly been derived from his bank lock but the other patents covering engraving were merely a protective measure. Of profits from the later nail machine patents nothing is known. If these past years had been fruitful of mechanical benefits, they had been procured by incurring many debts and were barren of monetary gains. Perkins' creditors now became very restive, more especially as he had removed himself from their direct orbit and seemed to them to be making no attempt to liquidate the indebtedness. These creditors, of whom there were some twenty-five, gaining but little satisfaction by direct appeal, finally turned to his brother, Abraham Perkins, demanding that he use his influence and efforts to collect their money. Abraham, realizing the justice of their claims in spite of their inconvenience, decided to come to Philadelphia and see what could be done about the matter. He arrived toward the end of July, 1817, and he must have expressed himself very forcibly to his brother, because on July 30th he obtained two notes each for $1,750, signed by Perkins and endorsed by his Philadelphia partners, Murray and Fairman. One of these notes was to be paid in twelve months without interest, and the other in two years bearing the regular interest rate of six per cent.



PATENT FIRE ENGINE AND HOSE PUMP MANUFACTORY.

JACOB PERKINS & THOS. P. JONES,

Have entered into partnership, under the firm of

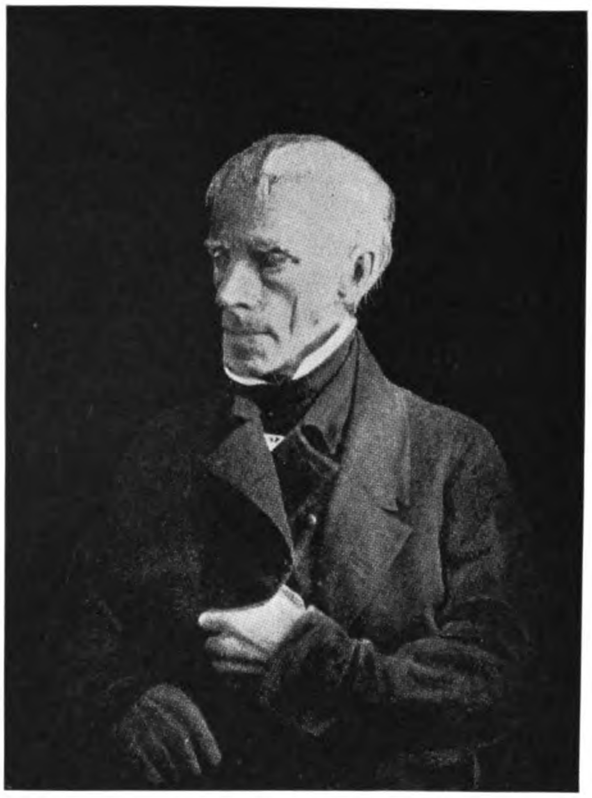
PERKINS & JONES,

AND established a manufactory of the above articles, at the back of St. James's Church, north Seventh near Market street.

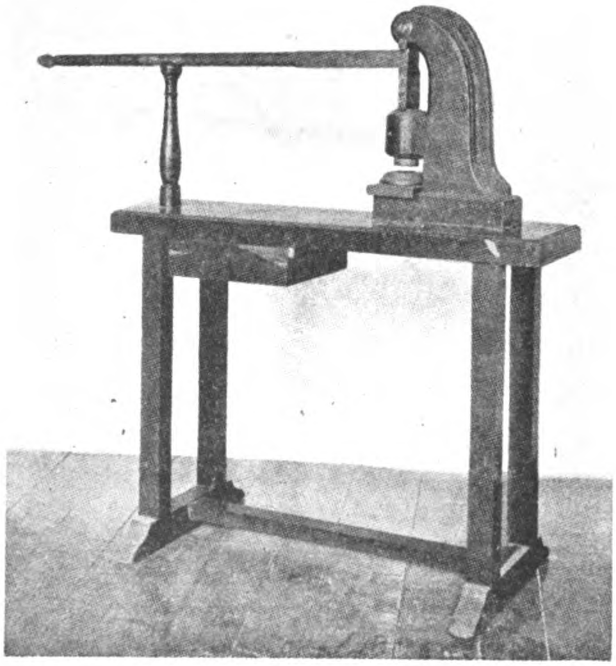
Their improved Fire Engines are made of various sizes, they are simple in their construction, and consequently not liable to get out of order; they will be furnished at less than two-thirds of the price charged for Engines of the same power upon the ordinary construction. Their Village Engine, which is of the third class, is equal in power to what is usually denominated the second class of engines, and may be had for 250 dollars. Their Domestic Engine, which is light and portable, will be found worthy the attention of every house keeper, whether cleanliness or security against fire be consulted; for watering gardens, they are superior to those formerly used, and are much lower in price. Gentlemen are invited to call and see them in operation.

August 19 tuif

Advertisement announcing the partnership of Perkins and Dr. Jones. From the *Aurora*, August 19, 1817.



Dr. Thomas P. Jones, aged about 65 years. *Reproduced by courtesy of the* Franklin Institute.



The Progressive Lever Press.

Perkins' Seal Press of 1819. *In the possession of the* Philadelphia Contributionship Insurance Company.

For some reason of his own that does not transpire, Perkins requested his brother Abraham to transfer these two notes to one Arthur Gilman for him to collect and disburse the amounts owing. Shortly thereafter Gilman himself became financially embarrassed and was forced to hand the notes over to Joshua Greenleaf and Samuel Emerson, two of the creditors, who proceeded to settle the matter forthwith, making poor Abraham Perkins the responsible party, though, as will be well understood, he was but a go-between. In Abraham's own words[94] "The said Jacob, did request me to transfer said notes to Arthur Gilman for him to collect for the benefit of said creditors, which I did merely to negotiate them as is well known to all or most of the parties concerned. Not being instructed I never had any idea of being accountable for all this amount as it was never intended I should be." Nevertheless Abraham Perkins was compelled to pay his brother's debts for it is clear that the notes were not met on their due dates, the first in 1818 and the second in 1819. It was not indeed until 1834 that Abraham finally paid all and settled in one way or another these obligations of his brother's.

After Abraham's return to Newburyport, it was decided that the time was now propitious for the removal of Jacob Perkins' family to Philadelphia and they arrived there in November of 1817. The family party consisted of Mrs. Perkins, Angier March the second son, four daughters and Joshua Butters Bacon, who had married the Perkins' eldest daughter Sarah about 1814.

In the *Aurora* of August 19, 1817, is to be found a notice to the effect that Jacob Perkins and Thomas P. Jones had entered into partnership under the firm name of Perkins and Jones, Patent Fire Engine and Hose Pump Manufacturers. Undoubtedly this partnership venture was born of several years of amicable business association between Perkins and Jones but its culmination at this time reveals a more definite reason, which was that of Perkins settling down to serious business and adequately providing for his family. Also at this time there was an urgent need by the citizens of Philadelphia for something more up to date and efficient in the way of fire fighting apparatus. There was at this time in the city no lack of volunteer fire companies, but the bulk of their engines and equipment was almost as antiquated as it had been in 1718, at which period the first engine was purchased by the city fathers for the comfortable sum of £50.

In 1803 the first sewed leather hose was made for the "Original Institution," a volunteer company. It was two and one-quarter inches in diameter and cost for the total length, of six hundred feet, forty-three cents per foot. In 1807 the hose reel was first used in Philadelphia. Up until then the hose was merely coiled in the bottom of the hose carriage. Sometime during 1814 James Sellers built "a combination apparatus," which was a carriage that had the pumping engine and the hose combined. This machine was called a hydraulion. As sewed leather hose so frequently burst through the threads rotting away, riveted hose was first suggested in 1811 and eight hundred feet were made by members of the Philadelphia Hose Company, the leather work being done by Jenkins and Son, saddlers, at a cost of $2.00 per day. The rivets were specially made in Wilmington, Delaware. The fire company wished to patent this improved hose but the idea lapsed and sometime afterward James Sellers, in partnership with A. L. Pennock, a member of the Philadelphia Hose Company, began to manufacture it on their own initiative. The total amount of fire equipment at the time Perkins and Jones commenced their business is indicated during a meet-

[94] Affidavit by Abraham Perkins, January 29, 1834, in the Perkins Papers, The Essex Institute.

ing of the city firemen at the Fourth of July celebration in 1818. They then declared "there are now in the city and Liberties thirty-four engines and fifteen thousand feet of hose under the direction of forty-nine companies."

The fire engine manufactory established by Perkins and Jones in 1817 was located behind Saint James' Church on North Seventh Street.[95] See Map 5 at B. The building used was a commodious stable and coach yard and here manual pumpers of several sizes and designs were built. These consisted of an improved fire engine, a smaller village engine, and a domestic engine for watering gardens. The pumps used in these engines are shown on page 84, from a patent specification of a later date, but they are all on the same general construction as the earlier triangular valve pumps, except that instead of having square cases, the pump barrels were round. The pistons of these pumps were a combination of plunger and bucket and in conjunction with a novel form of air vessel, shown at NN, Drawing 3, gave a continuous stream of water without pause.

On the evening of June 9, 1818, Perkins and Jones gave a demonstration in the public street of one of their improved pumps. The notice of this event from the *Aurora* reads:

> Perkins and Jones will make an experiment with their newly invented Supply Pump, at 6 o'clock this evening, in Seventh between Market and Arch streets. The intention of this Machine is to save the water which at present runs to waste, after having been once played from the fire engines. By its aid, the same water may be used repeatedly, and a constant supply be obtained, which under the present system, cannot be accomplished, notwithstanding the activity and zeal of those excellent institutions—the Hose Companies.
>
> This instrument, it is confidently believed, will become a powerful auxiliary in the extinguishing of fires, whilst it may save one half of the water usually drawn from the reservoir of the water works. Its construction is such, that it will not take up sand or other particles, which might injure the engines, and it may be made so light, as to be readily carried and worked by one or two men.
>
> Members of Hose and Engine Companies, and others who take an interest in the improvement of machines for economising water in the extinguishment of fires, are invited to attend.

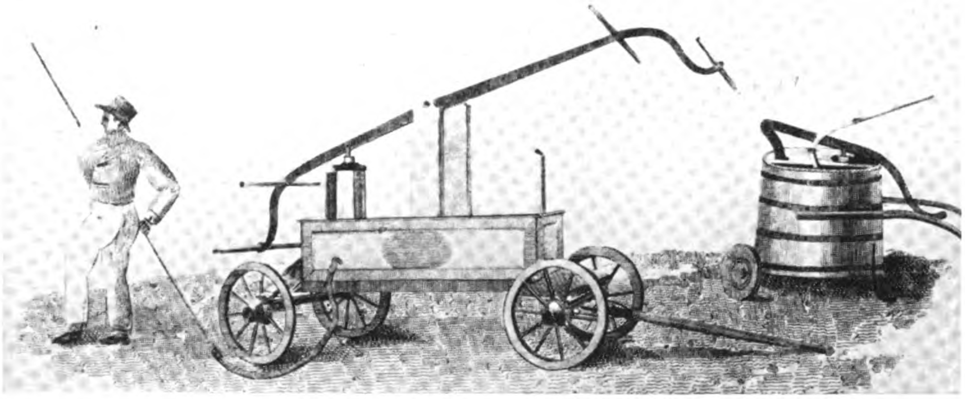
Apparently this piece of apparatus was an auxiliary pump which was intended to reclaim the water which ran into the cellar of the burning building and return it to the supply cisterns of the fire engines.

On June 22nd Perkins and Jones began a series of almost daily advertisements in *Poulson's American Daily Advertiser* for their various types of pumps and other equipment. These business notices ran until the end of December and read as follows:

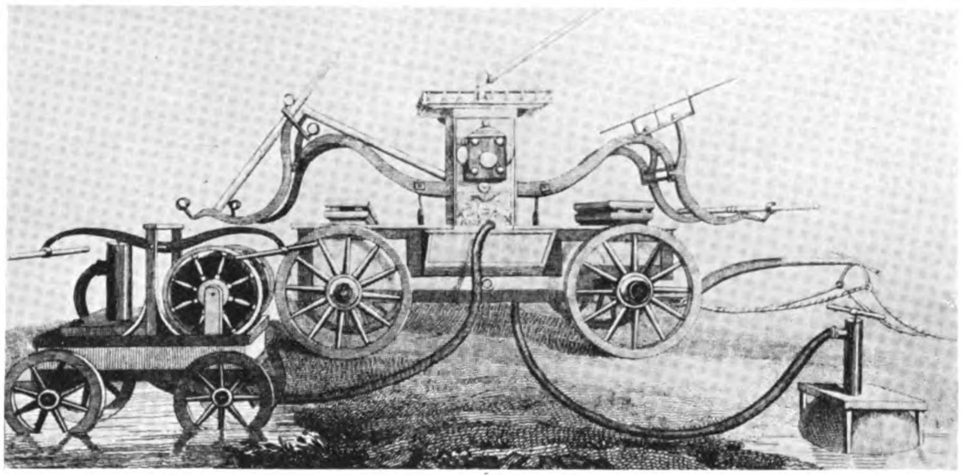
> Perkins & Jones, Back of St. James's Church, North Seventh street, Philadelphia.
>
> After a series of experiments, by which they have brought their Patent Hydraulick Machines to a high state of improvement, and ascertained the best proportions and modes of working, are now prepared promptly to execute all orders in their line of business.
>
> Village engines, which will play over a four story house, and not requiring more than eight men, will come at 250 dollars.
>
> First class do. throwing a larger stream and holding more water, 300 dollars.
>
> Adding to either of the above, their improved Copper Suction Pipe, by which the Engine supplies itself or other Engines from a pond or gutter, 50 dollars.

[95] St. James' Church, built during 1808-1809, faced on Seventh Street with a small burial ground to the rear. On the south side was St. James Alley, now called Commerce Street. The Perkins and Jones Manufactory was off this narrow street between Seventh and Sixth Streets, behind the church yard. No trace of the business premises now remain.

Fire Engines Invented by Jacob Perkins and later Manufactured by S. V. Merrick and Company.



A First Class Village Engine and a Domestic Engine in Oval Tub.



A First Class City Engine and a Small Village Engine with Hose Reel.

A Perkins Patent Fire Engine as made by S. V. Merrick and Company. *Circa*, 1825. *In the possession of the* Bucks County Historical Society.

If the copper tube is lengthened to raise the water from a well, or upon a wharf, which may readily be done about 18 feet, the charge will be 3 dollars extra per foot.

Their largest sized Engines, which cost one thousand dollars, will discharge a ton and a half of water per minute, and project it upwards of 180 feet, through a nosel one inch and an eighth in diameter.

Intermediate sized Engines, at proportionate prices.

Domestic Engines for watering gardens, washing windows, &c. at 42 to 45 dollars—if with copper plungers, 5 dollars extra. Large sized do. used in factories, &c. as Fire Engines, 100 dollars.

Their new Supply Pump, which will return the water that usually runs to waste after having been played upon a fire, or will force it from a pond, &c. through hose, to any required distance—from 60 to 100 dollars. The cost of hose, will, of course, depend upon its length.

These Engines are simple in construction, not liable to get out of order, and may be repaired by an ordinary mechanic. Their simplicity enables the inventors to sell them at little more than half the price of those on the English construction. They have but one chamber, with the whole effect of two—but half the number of valves and other appendages, and less than half the friction. The stream is constant, and so compact, as to produce less spray than any heretofore made.

Letters of inquiry post paid, immediately answered, and ample instructions given, when Engines are forwarded. Payments may be made in Philadelphia and interest charged after 60 days.

This advertisement contained a request that the notice be copied and inserted weekly for three months in the newspapers of the cities of Boston, New York, Baltimore, Washington, Richmond, Norfolk, Charleston and Savannah, their bills to be forwarded for payment to Perkins and Jones. Undoubtedly the expense of this prodigious advertising campaign was staggering, all the more so because the company was not as yet in any financial position to handle business of such a far reaching nature. It is evident that the conservative and scholarly Dr. Jones took alarm and the upshot of the matter is contained in the following newspaper notice under the date of February 15, 1819:

NOTICE

The co-partnership heretofore existing between the subscribers under the firm of Perkins and Jones, is this day dissolved by mutual consent. All persons having demands against the said firm, and those endebted to them, will make settlement with Jacob Perkins, who is fully authorized the same.

JACOB PERKINS
THOMAS P. JONES.

The business for a few months was then continued by Perkins alone and in addition to the fire engines, he began to make an escape and hose ladder which ran on a wheeled carriage. The hose was carried up the ladder which enabled the water to be directed into the upper stories of the building. In fact, this was the forerunner of the modern water tower. He also repaired the earlier types of fire engines at his establishment and improved their pumps "to make them play farther."

But the most significant turn in Perkins' affairs, foreshadowing as it did his leaving Philadelphia, was a series of notices which he published between February 15 and May 18, 1819, in the *Aurora* in which he offered to dispose of many of his inventions on terms of sale, or royalty, for others to make and use. These inventions included the bank vault lock, the nail and brad machine, the cylindrical copper plate press, the patent for relieving back

water in mills, the bathometer, the orthometer and the pleometer; a lever seal press for offices, one of which Perkins said "is in use at the Mayor's and another at the Philadelphia Insurance office." See Plate XIV. The portable lever press, above mentioned, for embossing notary and other official seals on documents, is described in the *American Daily Advertiser* as follows:

PROGRESSIVE SEAL LEVER PRESS.

One of these Presses is now used in the General Land Office, in this city, and proves to be far superior to the Screw Press. The lever is about three feet in length. The makers and patentees (Perkins and Bacon, of Philadelphia,) calculate, correctly, that a power of one hundred pounds, applied at the end of the lever, will produce a momentum, equal to a weight of thirty thousand pounds, at the moment when the lever is brought to a horizontal position.

The seal may be impressed about ten times faster than by the common Screw Press, and by a power much less than one hundred pounds. The impression is perfect and complete.

The progressive lever press was patented by Perkins on February 27, 1819. It was of the variety known as a toggle joint press. The principle of this machine was applicable to a variety of uses, such as the platen of the printing press, pressing out oil, cutting, punching and embossing metal, the baling of tobacco, wool and cotton. There is some evidence that Perkins sold the privilege of using his lever press to General David Bradie Mitchell for use on his cotton plantations in Georgia and an agreement to this effect is to be found in the following document: [96]

Philadelphia, April 19th 1819.

We, the undersigned hereby agree to sell Genl. Mitchell, the sole and exclusive right to a Progressive Lever Press (so called) patented by Jacob Perkins in March, 1819, so far as it shall be applied to the packing & preparing of Cotton in the raw state—for the whole United States for Forty Thousand Dollars, or for the State of Georgia, for Fifteen Thousand Dollars, and either case, one half the Money to be paid down, and the other half to be paid when the right shall have produced the sum stipulated to be paid and before any profit shall be realized by the purchaser and we further agree to warrent and defend the said right to him or his assigns against the lawful claims of any claim of any person or persons whatsoever—

Jacob Perkins
G. Fairman

The sums mentioned in this document are considerable, and if Perkins really put this deal through, he did remarkably well with this single invention. General Mitchell [97] was an extremely wealthy southern planter, so if the transaction was not consummated it could not have been because of financial reasons. The joint signatures appearing on the bottom of this paper indicate that some kind of private agreement had been entered into between Perkins and Gideon Fairman, that gave Fairman a share in the sale.

The partnership which had hitherto existed under the firm name of Murray, Draper, Fairman and Company expired in July, 1818, by its own limitations and John Draper then

[96] Manuscript Room, The New York Public Library.

[97] David Bradie Mitchell, lawyer, born in Scotland in 1766, died at Milledgeville, Georgia, in 1837. He inherited his uncle's property in Savannah in 1783 and was elected Solicitor General of Georgia in 1795 and was appointed Major General of Militia in 1804 and was Governor of the State from 1809 to 1813 and again from 1815 to 1817.

withdrew. The firm was then continued under the style of Murray, Fairman and Company. Perkins' name never appeared in any official capacity connected with the engraving company yet it is fairly certain that he had some kind of working agreement with regard to his special services at the plant. That these could not have been very exacting is evident from the amount of time he was able to devote to other things. Perkins would undoubtedly have received recompense or royalties on any of his inventions used by the firm but it is quite impossible to say how many of these were at that time actually under his own control.

Perkins' regular attendance at Sansom Street after 1817 must have been considerably curtailed and his hasty visits there snatched from his fire engine business could not be considered in any other light than that of consultant to the firm. The actual engraving of the bank note designs was done by Fairman, Charles Toppan[98] and others and in the beginning Perkins had superintended the mechanical processes necessary to producing the dies and plates but more diverting interests had long precluded any desire by him for prolonged efforts at the furnace or the engraving bench.

In February of 1819, Perkins went to Washington on business in connection with the firm's work for the United States Bank, and also to attend at the Navy Yard on the Anacostia River with regard to his instruments to be placed in the frigate *Columbus* then being completed.

While in Washington, Perkins offered to the Navy Commission a method of testing anchor chains,[99] then just coming into use in the navy to replace the earlier hempen cables. From the "Navy Commissioners Journal" of this period was culled the following, dated February 18, 1819:

> Jacob Perkins (present) respecting his power for testing chain cables, attached to the machine for making 8 sided tree nails. The Commissioners having been informed that Mr. Perkins can attach at a moderate cost, to the machine for cutting eight-square tree nails, a power for testing chain cables, request that he will give a specimen for the satisfaction of the Board.

The tree nails mentioned were used for spiking the sheathing to the timbers and ribs on the new warships. These tree nails were made of hard wood, roughly shaped down to size and then forced through an eight-sided hollow die which made them all of uniform dimensions. To this machine Perkins suggested using a more powerful attachment, probably based on his toggle joint lever press, to prove the links of the anchor chains. Under the same date, February 18th, Commodore Rodgers replied to Perkins' offer as follows: [100]

---

[98] Charles Toppan, born February 10, 1796, at Newburyport. He was a nephew by marriage of Jacob Perkins. In 1814 Toppan went to Philadelphia as assistant to Murray, Draper and Fairman. When Perkins went to England in 1819, Toppan accompanied him to London as his chief engraver. Returning to America many years later, he joined with Draper again, under the firm name of Draper, Toppan, Longacre and Company, carrying on business in Philadelphia. The firm name afterwards became Toppan, Carpenter, Casilear and Company. In 1858 this firm combined with others to form the present American Banknote Company of which Charles Toppan was for many years the president. He died November 20, 1874, at Florence, Italy. George Murray, the senior partner of the original firm, was born in Scotland and came to America as a portrait engraver in 1796. He came to Philadelphia about 1800, in which city he died in 1822. John Draper is best remembered for his engravings in Thomas Dobson's American edition of Rees' *Cyclopaedia* (1805-1825). Draper's name appears in the Philadelphia Directory until about 1852.

[99] Chain cables were first introduced into the British Navy in 1812 and probably into the American Navy by 1817.

[100] *Miscellaneous Letters from Navy Commissioners,* Folio No. 1, p. 514.

A Bid for a Grand Prize

Navy Comm Off
18 February 1819

Sir:

The Board of Navy Commissioners understand that you can, at a moderate expense, attach to the machine for making tree nails 8 square, a power competent to test chain cables—and request that you will do so— It will readily occur to you, Sir, that the machinery affording this power should be such as can be worked by a few hands—and so graduated that a greater or less power can be applied, agreably to the scale given to you.

Respectfully
Yr Mo Ob S.
John Rodgers.

Jacob Perkins, Esq.
Washington,

That Perkins was able to complete this work for the Navy Commissioners is unlikely as the following turn of events will show.

It is probable that during his stay in Washington, Perkins had had a personal interview with Charles Bagot,[101] the British Minister. Bagot's acquaintance with Perkins dated from 1816 at about the period which ushered in the Second National Bank. At that time Bagot had been deeply impressed by the beautiful work produced from Perkins' steel plates and had urged their adoption in his own country. This wish had culminated in the urgency of the Bank of England authorities to find a system for producing their bank notes so that forgery could be eliminated. To this end the bank offered a large cash prize to encourage the submitting of some practical method to do away with this evil. Whether this trip to Washington was the real starting point of Perkins' sudden determination to try for the prize offered by the Bank of England is not known. Perkins had been in communication with Charles Heath,[102] the engraver of London, during 1818 and Heath had shown specimens of Perkins' work to a committee of the Society of Arts in that year. Also there had been correspondence between Perkins and Joseph C. Dyer, who was insistent that Perkins come to England and establish his engraving methods there. Dyer, by way of preparing for this, had on September 28, 1818, laid before the bank authorities Perkins' invention for printing bank notes from steel plates.

Immediately upon Perkins' return from Washington, he went into conference with Murray and Fairman with regard to the many financial advantages which would accrue to the firm if they could win the grand prize and also secure a substantial contract into the bargain. Perkins' associates, with more conservative emotions, considered that at least there would be a considerable field in England for their siderographic engraving even if the prize did not fall to their lot. There is no doubt that Perkins' enthusiasm was an overwhelming factor in a very hurried decision by the firm. This decision, as it finally crystallized, was that Perkins should sail immediately for England, taking with him all the necessary machinery and equipment as well as a staff of engravers and workmen, among whom were Fairman, Charles Toppan, J. W. Carpenter [103] and Asa Spencer, the latter being the inventor of an improved geometric lathe.

[101] Sir Charles Bagot, 1781-1834, was Minister Plenipotentiary to the United States from 1815 to 1819. At this time he had not received his knighthood.

[102] Charles Heath, son of James Heath the academician, was born in 1785 and died in 1848. He had two sons, one of whom, William Heath, was an engineer and the other Frederick Heath, was an engraver.

[103] Of these names, Fairman, Toppan and Carpenter were the engravers. Asa Spencer was the machinist and

In 1815, or perhaps earlier, Perkins had become acquainted with Asa Spencer,[104] a watchmaker of New London, Connecticut, who in the course of his profession had perfected a special kind of engine lathe for engraving flat, convex and concave surfaces. This lathe produced very intricate patterns known as water-line engraving. It is said by Perkins himself that he purchased the rights to this machine in August of 1815. This geometric lathe, a copper and steel plate printing press, which by slight alteration to the roller could also be used for coining and embossing metal, was patented by Perkins in England on October 11, 1819.

In the middle of May, Perkins and Toppan went up to Newburyport to say farewell to their families and friends, and to bring with them on their return Asa Spencer, the chief mechanic of the party, from his home in New London. Perkins, as he made his adieux in Newburyport, could have little thought that he was seeing his native town for the last time. His wife and second son, Angier March, and his four daughters were to join him in London if the business justified his staying on; his eldest son, Ebenezer, was to accompany him. The news that Perkins was going abroad to compete for the prize offered by the Bank of England began to spread and many wild and sensational stories were published in the newspapers, of which the following is a sample. This appeared in the *American Daily Advertiser* of Philadelphia on May 25th and 26th:

New-London, Connecticut, May 19.

Messrs. Perkins and Tappan, engravers, from Newburyport, passed through this place on Monday last on their way to London—where they are to be employed in engraving for the Bank of England. Mr. Bagot, we understand, has paid them in advance 5000£ and if they succeed in their business, of which there can be no doubt they will also receive 100,000£ in addition. Mr. Fairman, of Philadelphia, is also attached to the company.

This tribute of respect to the genius of our countrymen is certainly gratifying.

Communication.

The three Engravers mentioned in the article from New London, as being employed by the Bank of England, are citizens of Philadelphia, and not of Newburyport as there mentioned; Fairman & Perkins are of the firm of Murray, Draper, Fairman & Co.—Tappan, who has been long in their employ, was the inventor of the Geometrical lathe. Perkins is well known to the citizens of this place, New York and Baltimore, as an Engine Builder. It is understood they go out in the Telegraph.

---

there were two assistant workmen, Marcus Bull and J. McCawley, to do the printing. These were to join the firm in London after a place of business had been decided upon. Spencer, Bull and McCawley all had contracts, Spencer's being for three years.

[104] Asa Spencer was born in New England, exact time and place, however, are undetermined. About 1800 he went to New London, Connecticut and married Elizabeth Hempster of that town in 1801. While following his profession of watch and clock maker, he invented a metal ruling machine for engraving clock faces and also copper and steel plates. This machine he patented in 1812. A mechanic of much ability, he had by 1814 brought his geometric engraving lathe to a point of great perfection and when Perkins came to Philadelphia in 1815, he introduced the lathe to Murray, Draper, Fairman and Company and it was adopted for use by the firm. Spencer's geometric lathe was fully described with numerous drawings, in Perkins' British Patent #4400, of 1819. After Spencer returned from England, he settled at No. 48 Sansom Street in Philadelphia and is listed in the 1825 directory of that city as an engraver. In 1841 Asa Spencer, Jr. engraver, appeared in the directory and this presumably was a son, born in New London probably about 1804. In 1844, the firm was listed as Spencer, Huffy and Danforth, bank note engravers, and so remained until 1847, which was the year of Asa Spencer's (senior) death.

For these highly fantastic statements, Mr. Zachariah Poulson, the publisher, was in the following letter firmly rebuked:

Mr. Poulson,

It has been with much regret that we have witnessed a number of Newspapers of late teeming with notices upon the subject of our private affairs, many of which are most grossly erroneous, and not one of them literally true.

Among the former are two pieces which appeared in your paper of yesterday and the day before, one copied from a New London paper, and the other purporting to be a Communication, both of which united, contain but one single fact, namely, that G. Fairman, belongs to the firm of Murray, Fairman & Co.

When we have any communications to make to the public, upon our Bank business, it shall be done with our proper signatures.

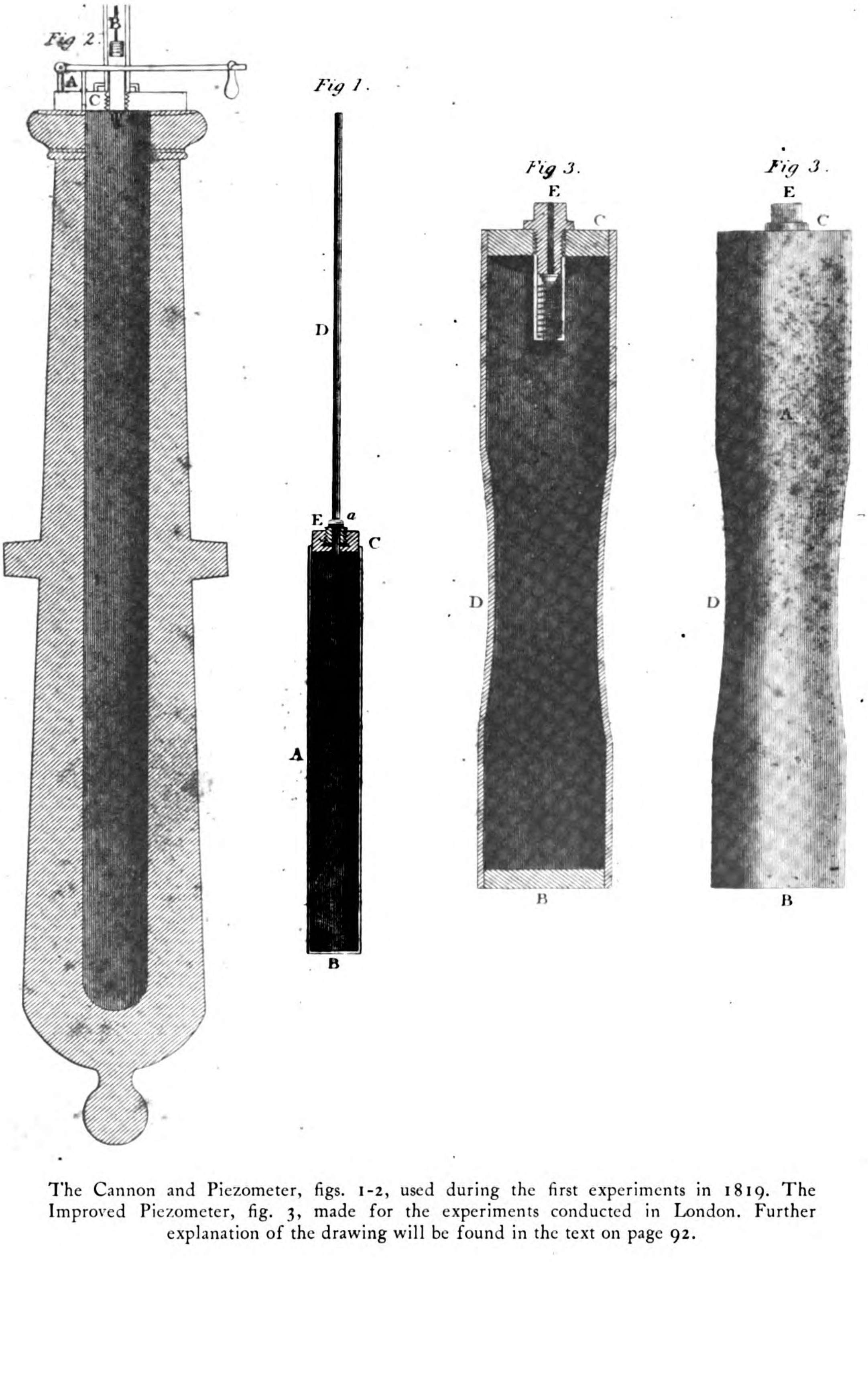
Murray, Fairman & Co.
Jacob Perkins.

Perkins' brief association with the American Philosophical Society in Philadelphia dates from about this period.

As early as 1811, at a meeting of the Society on February 15th, an account of Perkins' new copper plate press had been listened to with interest, but it was not until he had come to Philadelphia that any further contacts were made between him and the Society. Shortly before he sailed for England, he had brought to the notice of the Society the results of his experiments by which he proved that water was not only compressible but that the amount could be registered. Hitherto this liquid had been classed as one of the non-elastic fluids.[105] It seems probable that Perkins, while devoting his attention to improving his fire engine pumps, had observed certain phenomena in the properties of water while under high compression and speculating on this, had decided to make some definite experiments. To make these possible, Perkins obtained a disused twelve-pounder cannon from the Navy Yard and he converted this into a pressure chamber by screwing a cap onto the muzzle, and a plug into the vent. Into the cap he fixed a loaded safety valve, shown at A Fig. 2 Plate XVI. At C was screwed on a small force pump which could be worked by a lever. The Piezometer, for containing the water for the experiment, is shown at Fig. 1. This consisted of a small brass container, shown at AB Fig. 1, completely filled with water. A friction rod D, controlled by a rubber ring at E, prevented the rod from slipping into the chamber before compressing. The Piezometer was then inserted into the bore of the cannon when, after screwing on the cap, water was pumped into the cannon until the loaded safety valve showed a definite pressure by means of the graduated lever and weight. After the Piezometer was removed from the cannon, the rod D was found to have sunk into the brass container AB

[105] The extent of compression which water undergoes when subjected to great force had early engaged the attention of scientists. John Canton in 1762 conducted experiments with a column of rain water 33½ feet in height and produced a contraction of 46 millioneth parts. Other experimenters along these lines were Prof. Zimmerman of Brunswick, Prof. Œrsted of Copenhagen and Sir John Leslie. It was generally considered at this period that "An incompressible or non-elastic fluid is one whose dimensions are not, at least as to sense, affected by any augmentation of pressure, water, mercury, wine, etc., are generally ranged under this class." From the chapter on Hydrostatics, p. 336, of *A Treatise of Mechanics*, by Olinthus Gregory, 1807. Deep sea sounding such as Perkins did with a porter bottle has been vastly extended since then. It has been found that at a depth of six miles the level of the sea is lowered by its own compression 620 feet, with an average of 116 feet for the whole surface of the ocean.

The Apparatus Used by Jacob Perkins in His Experiments on the Compressibility of Water.



The Cannon and Piezometer, figs. 1-2, used during the first experiments in 1819. The Improved Piezometer, fig. 3, made for the experiments conducted in London. Further explanation of the drawing will be found in the text on page 92.

to an appreciable degree as indicated by the rubber ring, thereby showing that the volume of water had been compressed by that amount.

The first person to realize that liquids might be compressible long antedates Perkins' experiments and no special claim can be made for him as the discoverer of this possibility. However, there are authoritative records of Perkins' independent experiments made before the American Philosophical Society which should be borne in mind. In the proceedings of the Society[106] on April 16, 1819, it is stated that "Perkins referred to Robert Patterson, Robert Hare, and Eugenius Nulty to witness his experiments on the compressability of water by means of his instrument, the Piezometer." Again, on June 18, 1819, the procedings state "at a meeting, the committee on Perkins' machine reported progress." And it is notable that at this meeting, Perkins was elected a member of the Society in recognition of his scientific work. And again on November 5, 1819, "Perkins' experiments with his Pyometer and Bathometer during his late passage to London were referred to Patterson, Hare and Nulty." And again on February 18, 1820, another reference is to be found in the proceedings, to the effect that "on Perkins' experiments, committee continued." As these experiments of Perkins with water were resumed and the results published later by the Royal Society in London, this subject will be again referred to.

There is every reason to believe that Perkins, on the eve of his journey to London, did not in any way consider this step final. He made his preparations seemingly with the idea in mind of renewing his Philadelphia business associations after having established the London branch. The fire engine business had by now become a paying proposition and Perkins claimed that he had "disposed of more than two hundred engines within two years." This statement certainly indicates that there might have been considerable financial future in this line of work. Probably Perkins believed this, because he appointed his son-in-law, Joshua Butters Bacon,[107] to manage this business in his absence. The firm thus became Perkins and Bacon and advertisements were inserted in the *Aurora* during the summer of 1819 stating that "they will continue to carry on the fire engine and hose manufactory in all its branches."

Perkins assembled his party of adventuring craftsmen and made ready to sail on May 31st. Twenty-six cases of machinery were already piled upon the dock, ready to go aboard the fast sailing packet *Telegraph*, which was under the command of Captain Hector Coffin. Perkins had made careful preparations for furthering his experiments on the compressibility of water during the voyage. In addition to the Bathometer, he had constructed an instrument which he called a Pyometer, which was an adaptation of the Piezometer, for deep sea pressure sounding. Of these experiments made by Perkins during his voyage to England, it may be well to quote in part from his log: [108]

---

[106] *Early Proceedings of the American Philosophical Society, 1744-1838.* Printed and indexed.

[107] Joshua Butters Bacon was born on April 25, 1790, in Boston, Massachusetts. He married Perkins' second daughter, Sarah Ann, in 1814. At this period he was serving in the Light Infantry Company of Boston, in the defenses of the city. Bacon's original profession is not known. He is sometimes referred to by Perkins as "my attorney," but the American Bar Association has no record that he was ever admitted to the Bar. Bacon appears to have been a most excellent man of business and his loyalty to the Perkins interests was commendable at all times. Bacon died in London, England, on October 7, 1863, at the age of 73. He is buried in the Perkins family vault in Kensal Green Cemetery.

[108] *Experiments with Pyometer at Sea, June, 1819*—Manuscript Communications to the American Philosophical Society—*Natural Philosophy* Vol. II.

Philadelphia May 31 1819

This day at 12 o'clock left this city for London. The Steamboat "Baltimore" conveyed us on board the ship "Telegraph", Hector Coffin, Esq. commander, laying at Newcastle. We arrived at 5 o'clock got immediately under weigh the wind being fair we sailed at the rate of 6 knots. After a few hours sail it fell calm and obliged us to anchor."

June 1—Weighed anchor again at 3 o'clock and got out of the Capes—but were obliged to wait until morning to have the pilot taken off.

June 2—Pleasant breezes from the west—opportunity for making a few experiments [—Perkins mentions that the average rate of sailing was 5 knots until a calm fell on June 6th]

June 6—First experiments with the Pyometer—it was sunk with two deep sea leads to a depth of 500 fathoms—14 of the crew in two spells of 7 men took 30 minutes to bring it to the surface—Found that the plunger had raised 8 inches, indicating compressibility of one per cent [—Perkins also at this time made some experiments with an empty porter bottle hermetically sealed, at a depth of 150 to 200 fathoms traces of water were found inside the bottle when drawn up from the depths. Further experiments were dis-continued because of wind springing up]

June 8—Second experiment with Pyometer.

June 9—Bathometer experiment tried several times [—these were continued until June 11th]

June 13 Sunday—Very cold with fog off the Banks.

June 15—Sailed at the rate of 10 to 11 knots.

June 20 Sunday—300 miles from Cape Clear.

June 21—Both the Pyometer and the Bathometer were lowered down to a depth of 500 fathoms.

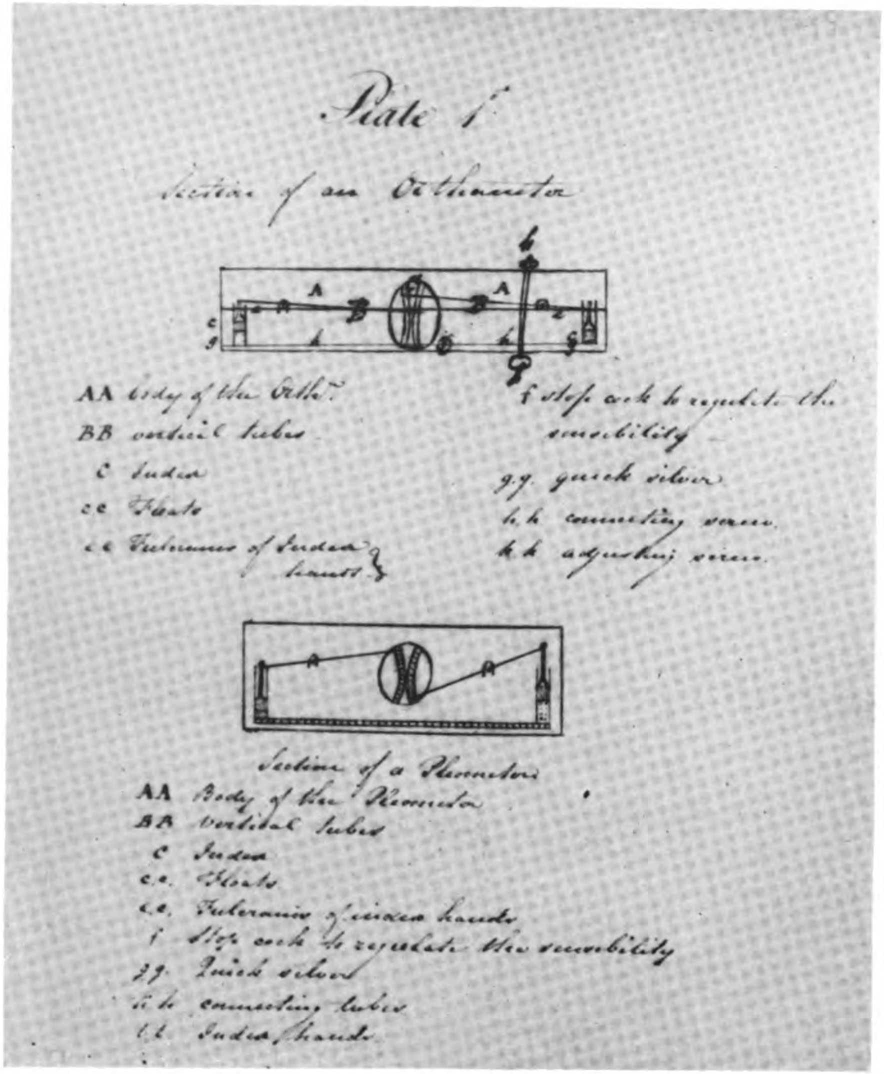
June 23—Off Cape Clear in 90 fathoms

No further experiments are mentioned by Perkins during the voyage. The ship was now off the southernmost end of Ireland and the water was not deep enough to continue the soundings effectively. Before leaving Philadelphia, Perkins had installed two of his navigating instruments, the Orthometer and the Pleometer, in the main cabin of the *Telegraph* for his personal observation and correction. His summary of their performances during the voyage is accompanied by his own sketches (Plate XVII), and reads thus:[109]

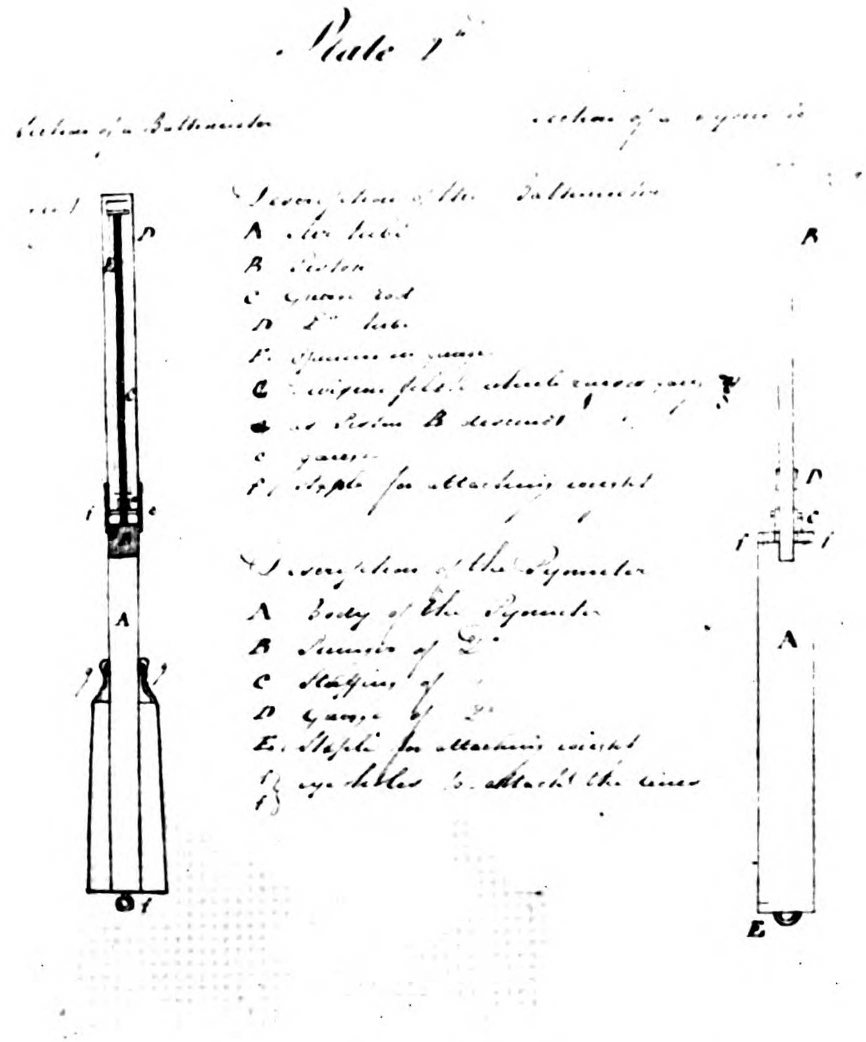
Observations made upon the operations of an Orthometer and Pleometer as used on board the ship "Telegraph", Capt. Hector Coffin, on her voyage from Philadelphia to Liverpool in the summer of 1819. These machines were fixed in the cabin of the ship by the inventor to enable him to make some practical observations, while on his passage to Europe, being the first time an opportunity has offered since their construction. These instruments had been used on board American vessels of war, and the principles on which they were formed found to be correct. The Pleometer—see Plate 1, fig. 1—for shewing the careen of the ship worked perfectly altho at times the ship rolled very much: yet the instrument was not the least sensible to it. It indicated only the careen of the ship. The Pleometer shews, with the wind, when it would be proper to shorten sail: it was also ascertained that the rate of sailing could be nearly told by it, to do this the direction of the wind should be taken into view. Many times when the log was thrown, the way of the ship was stated by persons in the cabin and found generally correct. The Orthometer—see Plate 1 fig. 2—which shews the trim of the ship operated well. It shews all the changes made in the ship by the removal of stores, etc. and sometimes it would indicate a pressure of head sail by six inches. It was also observed when the ship pitched much and sailing before the wind that the Orthometer would denote the ship being more by the head by 2 or 3 inches, there was the fact. By having this knowledge no difficulty would arise from the defect. The inventor having had an opportunity of witnessing the operation of these instruments in all the different positions of the ship is now able to make all the necessary improvements. In the Pleometer no alteration is necessary, the Orthometer may be much improved by lengthening the volumes of quick silver in the

[109] Manuscript Communications to the American Philosophical Society, *Natural Philosophy* Vol. II.

Original Drawings Made by Jacob Perkins of His Nautical Instruments.



The Orthometer and Pleometer used in the navigation of ships.



The Bathometer and Pyometer for deep sea soundings.

From the *Manuscript Communications* to the American Philosophical Society.

vertical tubes, changing the fulcrums of the pivots and making the machines less sensible. This improvement will remedy the defect occasioned by the unequal pitch of the ship when before the wind.

The passage to England had been uneventful and the party arrived at Liverpool about the 28th or 29th of June. The British Customs extended to Perkins the courtesy of not opening nor inspecting the cases of machinery and they were passed free of duty. During the voyage, Perkins had entrusted to Captain Coffin's care a letter to be delivered to the committe of the Philosophical Society upon Coffin's return to Philadelphia. In this letter, Perkins set forth the results of his experiments at sea: [110]

AT SEA
Ship Telegraph
Lat 41: 12 long. 60: 31
June 8th 1819.

Messrs. Patterson, Hare and Nulty,
Philadelphia.
Gents:

I have had but three opportunities of trying the Pyometer. It was at the exact Depth of 500 fathoms, say 100 Atmospheres, 300 fathoms & 200 fathoms. At 500 the ring on the plunger indicated 8 ins. at 300—5 6/8 at 200—4 1/8. I mean as soon as practical I shall repeat the experiments as well as to sound down at 100 & 400 fathoms. The Bathometer performs well, I have been able to get it at the depth of 50 fathoms while sailing 5 1/2 knots. I have tryed it all the different depths from 10 to 100 fathoms it always indicates the same but I find as the pressure increases the resistence increases in a much greater ratio than the common received theory. I shall however make many more experiments before I graduate it. At the time I let down the Pyometer 300 fathoms an empty bottle was also made fast to it—Capt. Coffin had taken great pains to secure the cork by covering it with 6 layers of canvas each layer saturated with tar & wax, only one inch of the neck was drawn up. This I have preserved for your inspection—the cork has been pressed into folds by being forced against the canvas by the expansion of the water, which must have passed through the canvas. I should have mentioned that it was first sent down 200 fathoms it came up without any other change than that of having about 2 large spoonfuls of water in it—before the bottle gave way, the canvas split on one side sufficiently to impress the folds in the cork. I will write more particulars from Liverpool or London.

I am, gents,

Respectfully yours
Jacob Perkins.

N.B.—I forgot to mention that Doct. Patterson had ascertained that 8 inches would give one per cent—& this according to my last experiments in this year we had about 100 Atmospheres when the plunger was drawn in 8 inches— Before the pyometer was sent down I told Coln. Fairman 500 fathoms should leave the ring up 8 inches.

Perkins stayed in Liverpool long enough to distribute to the local banks there specimens of the firm's work and to arrange a business meeting with Joseph C. Dyer, then living in Manchester. Dyer was to become the financial backer of the London branch of the engraving company. His share in the patent was high, he valued it at £12,500 but it was anticipated that the profits would be high also. Captain Coffin is said to have offered Perkins £25,000 for a half share of what Perkins expected to receive from the Bank of England, but whether this offer was accepted either as a whole or in part is not known.

[110] Manuscript Communications.

LONDON

1819-1849

BY THE end of July, Perkins and his party set forth by coach for London, and shortly after their arrival there, premises were taken at No. 29 Austin Friars where "Broad Street falls gently into Throgmorton Street," a location which was close to their goal—the Bank of England. The cases having by now arrived in the Thames, the machinery was speedily set up, ready for the expected business from the Bank and the hoped-for prize.

On July 30, 1819, Perkins wrote to Sir Joseph Banks,[111] then presiding over the Royal Commission[112] in Soho Square, offering his forgery-proof system of bank note engraving. But things moved slowly and it was not until November that any response from the Commissioners was obtained. However, hope still ran high, as the following letter, which Perkins sent to Captain Coffin in December, indicates: [113]

London Dec. 13th 1819

Hector Coffin, Esq.

My Dear Sir:

I have read with great pleasure your several friendly letters, & should have written you before, had not my time been constantly occupied— It is with great satisfaction that I inform you that so far, we have succeeded beyond our most sanguin expectations— Such is the demand for our plates for private banks, that we only wish for *the honour of the thing* that the Bank of England should *at present* adopt our plan— That they will be finally compelled to do it, I have no doubt in fact, all the people declare it must be so— We were told yesterday from the best authority that one of Sir Willm. Congreaves' workman had said, that Sir Willm. had been as cross as a bear, ever since our specimens were exhibited to the commissioners, that he had said that he expected the American plan would be adopted, altho it was not any better than *his own*. He has shown me his plan— I will put ours against his, he may take five years, we five days & he that imitates the amount, shall accrue from the other £1,000. In fact he does not know enough to know he knows nothing of the practical part of the business. It is

[111] Sir Joseph Banks, 1743-1820, naturalist and botantist, president of the Royal Society of London from 1778 until his death, June 9, 1820.
[112] The Commission consisted of Sir Joseph Banks, Sir William Congreve, William Courtenay, Davies Gilbert, Jeremiah Harman, Dr. William H. Wollaston and Charles Hatchett and was appointed by the Government to find a practical solution for preventing the forgery of bank notes. The first charter of the Bank of England was granted on July 27, 1694. The bank was then styled "The Governor and Company of the Bank of England." The capital was £300,000, raised by public subscription and the whole amount was filled in ten days. Coming down to our period, an Act (Stat. I Geo. IV. Cap. 92) in 1820 was passed for the further prevention of forging and counterfeiting of bank notes. This supplemented an earlier act in 1801 which was "for the better prevention of forging of notes and bills of exchange of persons carrying on the business of bankers." The penalties for forging at that time were, for a first offense, imprisonment of two years or less than six months, and for a second offense, transportation for seven years. For engraving a spurious note, the penalty was for first offenders, three years' imprisonment and not less than twelve months with seven years transportation for a second conviction. At this period (1820) it was the usual procedure to return all forged notes to the parties presenting them, after having stamped each note in several places with the word "Forged." The Act of 1820 expressed a wish that "the names of persons authorized by the Bank directors to sign notes, might be impressed by a machine instead of being subscribed in the handwriting of such person."
[113] Rare Book and Manuscript Department, Boston Public Library.

fortunate for us, that a majority of the commissioners are *clever*. My friend the Coln. has given you the particulars, We are about getting up a large establishment, when done, & under good *way*, I hope to have the pleasure of returning with you & Mrs. Coffin. Our experiments, which you were so kind as to assist in making, has been well received by the Royal Society acknowledged to be new, & the machinery by which it is demonstrated to be unexceptionable—I requested many persons (who witnessed it) not to publish the facts until I had made a course of experiments, which I mean to do as soon as time will permit. We shall send you an American plate on Saturday the box will contain one for Mrs Perkins and one for Miss Wattles—We have also sent you a list of names, containing many of the first artists, engineers, & men of science—We are quite overwhelmed with the liberality of and good wishes of the artists, engineers, etc, etc. From 12 till 2 we were overcrowded with the curious and there appears no to opinions upon the utility of adopting our plan—*At any rate if the BANK do not adopt our plan we shall make more money than we expected to have done by the adoption of it by them* The field is immense we are extremely sorry we have not had the pleasure of seeing your self & your good wife of whom we often think and speak—excuse this hasty letter, I have not time to copy another—please to give my most respectful compliments to your kind and very excellent wife—Be so oblidging as to call & see when you return *my kind and very excellent wife*.

From your friend,

Jacob Perkins

No doubt this optimistic and informative letter written by Perkins to his seafaring friend back in Newburyport gave every assurance of immediate success, for it is clearly indicated that Captain Coffin had more than a passing interest in the Bank of England's acceptance of Perkins and Fairman's proposals. Captain Hector Coffin was born in Newburyport in 1783 and was a son of Dr. Charles Coffin of that town. He had married Mary Caswell Cook in 1808. Captain Coffin at the period now under consideration was only 36, but his enterprise, courtesy and generosity had already made him one of the most respected shipmasters on the Atlantic seaboard. Captain Coffin, like so many men who follow the sea, upon his retirement took up agriculture near Newburyport and died there in 1846.

With all these delays, Perkins and Fairman began to feel the shortness of ready money as they were, apart from themselves, responsible for the maintenance of the other members of their staff. Perkins wished to refrain from seeking any other work until the decision of the Commissioners was made known but the more practical Dyer urged the firm to engage in whatever other bank engraving work could be obtained to tide the situation over, for he as principal investor in the business was anxious to see it on a production basis.

Dyer had made every effort to promote the Perkins system in England and had published in 1819 and circulated among the Commissioners, a pamphlet entitled [114] *Specimens and Descriptions of Perkins's and Fairman's Patent Siderographic Plan to Prevent Forgery*. This booklet contained specimens of Perkins' and Fairman's bank notes and the names of over eighty backers of the plan, among whom were the following well-known engineers, Marc Isambard Brunel, Henry Maudslay, Bryan Donkin and George Rennie. The Commissioners' report dated January 15, 1819, which was presented by the Chancellor of the Exchequer before the House of Commons on January 22nd, said: "From America which affords the closest parallel to the state of England in this particular, *no official return has as yet been received*, but we have reason to think that in several parts of the United States the crime of forgery is prevalent, and that great efforts are now making to give notes such a character as may baffle the skill of the American forger. Specimens

[114] Taylor Collection, of the American Antiquarian Society.

An Introductory Circular to sound out Public Opinion on the Perkins and Fairman Plan for Bank Note Engraving. *Reproduced by courtesy of the* American Philosophical Society.

OPINION AND REMARKS

UPON THE

Means of Preventing Forgeries.

The prevention of the Forgery of *Bank Notes*, having become an object of great, and continually increasing *national importance;* not only as being necessary to afford a just security to our daily business transactions, but as alike requisite to uphold the character and reputation of our laws and tribunals for the administration of justice; and above all, as being deeply connected with the cause and best interests of humanity; WE, the undersigned, have been induced to examine, with considerable attention, the merits of the several plans which we have respectively seen and heard explained, as having been proposed for the attainment of that desirable object.

Among the plans so examined, we deem it proper to state, that the one proposed by Messrs. PERKINS and FAIRMAN, has our decided preference, for the following reasons.

At the request of those gentlemen, we have severally entered into a minute investigation of the principles upon which their plan is founded, as well as of the machinery and apparatus with which it is carried into effect. In order, therefore, to forward the great object in view, we conceive it may be useful to state the result of such investigation.

It appears, then, (1.) That this plan affords the means of producing and multiplying exact *fac similies* of all the different kinds of engravings; as executed by machinery, with the engraving tool, and by the action of acids through the interstices of a ground; whereby the peculiar style of *each original engraving* may be accurately preserved and perpetuated *ad infinitum*.

(2.) That *any number* of the most distinguished artists may be employed *at the same time*, to engrave all the different kinds of work upon *separate plates*, (previously prepared for the purpose,) and when completed, the whole of such engravings may be transferred and perpetuated as above, in a state of *intimate combination upon one plate*. Supposing, for example, twenty-five artists to be employed at once, each to make an engraving that would require two months to complete, the combination of all these engravings upon *one plate*, would concentrate the labour of *more than four years*, which period could not be shortened by any combination of counterfeiters, in attempting to make an imitation, seeing that in such attempt, only one at a time could work upon the same plate, and seeing that the forger could not resort to the same method, on account of the vast expense, and other obvious reasons.

(3.) That in addition to the bar thus opposed to the counterfeiter, by the concentration of so great a *quantity of work*, we are of opinion, that the *combination* of all the different styles of work as above stated, in the same note, would render it *physically impossible*, for any person to make an imitation that could be imposed upon the public as genuine, except it be by means of the like machinery and processes as are employed for making the originals. And that an important characteristic of this plan, consists in the facility with which the various engravings combined to form the figure of a note, can be *transposed at will*, so as *entirely to change its general appearance*, and by this means, the same original engravings may be used to form a great variety of notes, sufficiently distinct to produce the effect of entire novelty; and at the same time, a *perpetual identity* will be preserved in each individual engraving, the same as in types when transposed.

(4.) That even though it were doubted by some, whether the *quantity* and *combination* of all the different styles of work upon the note, as above stated, could be relied upon as affording adequate security against forgeries, yet still we think, this plan affords the means of putting an entire and absolute stop to this evil: for it has been shewn, that it would require four years continued labour to make an imitation, supposing it practicable at all; and to prevent the attempt, the Bank, upon issuing the notes, might proclaim that they would all be called in, within that period, and another form substituted by a transposition of the engravings. This would, of course, render it absurd for the counterfeiter to expend so much time in imitating a note which, when completed, would not resemble the new form to be put in circulation.

(5.) That upon the ground of economy, this plan possesses very great and obvious advantages, inasmuch as it affords the means of combining upon the notes, the most highly elaborated and beautiful engravings, of all the various kinds of work, the most difficult of imitation, to an extent sufficient, if need be, to cover their entire surfaces both front and back; and this, too, without any additional expense to the Bank ultimately, beyond what is at present actually incurred for engraving the simple form of the notes now in circulation. As in carrying this plan into effect, almost the whole of the expense consists in making the *first plate;* that is to say, the cost of the *original engravings* which are used as Dies, and of the *machinery and apparatus* with which these engravings are transferred and perpetuated; when one plate is so made, the same Dies, &c. will serve to make any number that may be required at *a very trifling* additional expense. Thus throwing the main expense upon the very first stage of the operation, and without incurring a very great portion of this first expense, the counterfeiter could not hope to make any sort of imitation.

(6.) That the security afforded by this plan, does not at all depend upon *any secret*, for if all the machinery and methods used for carrying it into effect, were shewn and explained to the counterfeiter, he would still have just the same expense to incur as above described, before he could make even the most distant imitation. And moreover, it is manifest, that neither the authors of the plan themselves, nor any other artists whatever, could make an *accurate* imitation of the work, without employing the *same original Dies* and machinery, and these would of course be given up, to be kept in the Bank, if the plan should be adopted.

(7.) That the *perpetual identity* of the separate engravings combined in the note, will enable any one to test the genuineness of any note, by simply comparing it with any other note, or with slips printed from the same originals with which every one may be furnished; and thus by an absolute guaging of the work, a forgery might be at once detected. The advantages embraced in this part of the plan are too obvious to require elucidation.

And finally, (8.) Considering this plan as embracing under the several heads already described, all the *desiderata* for rendering our paper circulation secure, and for putting an end to the crime of forgery, we have no hesitation in declaring our confident belief, that every competent judge, who will take the necessary steps to examine the subject, and to investigate the nature and merits of this plan, will concur with us in recommending it to our Banking Institutions for general adoption.

***London, Oct.* 23, 1819.**

NAME.	RESIDENCE.	NAME.	RESIDENCE.

Specimen of the engraving art of Perkins, Fairman and Heath, 1820. *Reproduced by the courtesy of the* American Antiquarian Society.

of these improved notes have been communicated to us by the *agent* of the American patentee, and have received our particular attention with regard to the practibility of adopting the invention."

Without doubt Dyer was the real moving spirit behind the whole plan for introducing Perkins' siderographic process into England and it is probable that Perkins never seriously considered any personal supervision involving a trip to London until he had been definitely urged to do so by Bagot in Washington sometime in February of 1819.

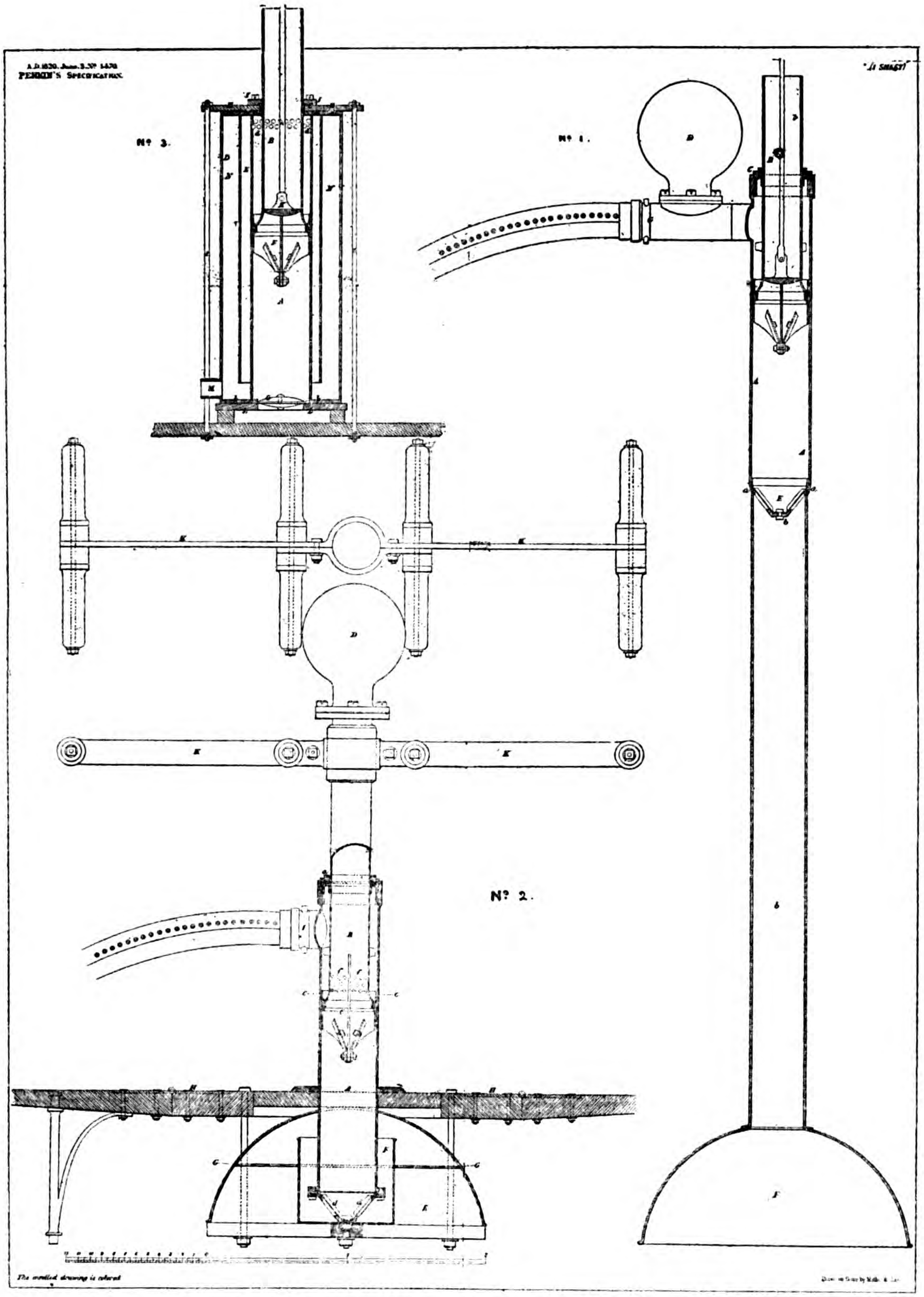
On December 20, 1819, Charles Heath joined the firm, which now became Perkins, Fairman and Heath. His monetary investment in the business is not known but as he became a bankrupt in 1821, it may be supposed that his financial help to the firm was not great. George Heath, his brother, was also an investor in the business but apparently did not take any active part in the work.

By February, 1820, it became almost a certainty that Perkins, Fairman and Heath were not to get the bank's work. Sir William Congreve,[115] then Governor of the Bank of England, had for some time past been actively engaged on a method of his own for preventing forgeries and was bitterly opposed to the "American System" as it was designated. In the early part of 1820, Sir William published a pamphlet [116] deriding the steel plate engraving process and claimed therein that his own workmen at the bank had successfully imitated several of the specimen notes which Perkins had submitted. This latter statement by Sir William was, at least in the main, only too true. His own engravers had produced equally good specimens as those of Perkins and Fairman even without benefit of the Asa Spencer geometric lathe but what was not proved was whether the Perkins system was really the better fitted to produce bank notes with the minimum likelihood of such being forged. Sir William Congreve was determined to eliminate Perkins and Fairman at all costs and to keep the production of the bank notes in his own hands. Engraving having been given a definite trial, Sir William was now ready to try some method of color production and Applegarth and Cowper, the Government printers of the bank's official dividend warrants and other script, were asked to try their skill in this new direction. A place was set apart for them on the bank's premises and Applegarth and Cowper, with their assistants, commenced work aided by a steam driven cylinder press and very shortly they were turning out notes of rainbow hues in five colors from type metal plates. Again the bank engravers, jealous of their professional skill, turned to and soon after managed to produce such exact counterparts of the Applegarth and Cowper notes by means of water colors applied by hand, that things were back again exactly where they had been in the beginning. It is no wonder that after this climax, the bank authorities and the Crown Commissioners decided to continue on with the notes then in use and these remained in circulation until

---

[115] Sir William Congreve, 1772-1828. An artillery officer in the Napoleonic Wars and in 1820, military governor of the Bank of England. Congreve was an inventor of some note; his patents cover improvements to gun carriages (1808-1812), manufacturing gunpowder (1815), a steam wheel (1818), a printing machine for printing in two or more colors simultaneously (1820), also improvements to fireworks and war rockets (1823). A military martinet of the old school, Congreve may be suspected of being deeply prejudiced at this period, against Americans and all their ways.

[116] *An Analysis of the True Principles of Security Against Forgery; exemplified by an Enquiry into the Sufficiency of the American Plan for a New Bank Note; with Imitations of four of the most Difficult Specimens of those Bank Notes, made by Ordinary Means*, by William Congreve, Bart., M.P., A.M., F.R.S., London. Printed by J. Whiting, 3 Lombard Street, 1820. Copy in the Taylor Collection of the American Antiquarian Society.



Various pumps shown in the specification of Jacob Perkins' British Patent of June 3, 1820. *From a copy obtained through* The Patent Office Library, London.

1837.[117] Thus ended all hope for Perkins and Fairman to gain what they had really come to England for but now that the suspense was over, the firm found plenty of demand for their excellent work in other directions.

It has been believed that Perkins was rewarded by the bank authorities to the extent of £5,000 as a consolation prize but there is nothing to substantiate this from entries in the company's books of that period. However, Perkins, urged on by Dyer, did claim compensation for his expenses, but that he ever received anything for these is extremely doubtful. With reference to the Perkins system of bank note engraving, there could never be any claim that it was absolutely forgery-proof. What man has done, man can do and the best that could be said of this or any other method, was that it reduced the chances of successful forgery to a minimum. A part of some correspondence between Langdon Cheves[118] and Murray, Fairman and Company, which appeared in the *American Daily Advertiser* on November 2, 1820, gives some direct testimony regarding the reliability of Perkins' American made plates:

Copy of a letter addressed to L. Cheves, Esq. President of the Bank of the United States, dated Philadelphia, 7th October, 1820.

Sir—We have just seen an article in Niles's Weekly Register, dated September 23d stating that our improved die work had been "successfully imitated." We have no doubt that Mr. Niles labors under a mistake, in making that statement for want of information, and that he has confounded the old dies, which we have abandoned for more than three years, with the improved dies now used by us—as we intend to write to Mr. Niles on the subject, we wish to learn from you, if, from any information you have received on the subject, you have reason to suspect that any plates executed by us for your bank and its branches, have been counterfeited, and you will be pleased to make the same enquiry as to any information the cashier or any other officer in the bank of the United States, may have received, as to any attempt at the imitation of the dies *now* used by us.

We are, very respectfully, Sir, your obedient servants,

(Signed) Murray, Fairman & Co.

Copy of a letter addressed to Murray, Fairman & Co. by L. Cheves, Esq. President of the Bank of the United States, dated 9th October, 1820.

Gentlemen—I have received your letter of the 7th inst. and have submitted it to Mr. Houston, the assistant cashier, (the cashier being absent,) and to both the tellers of the bank, and I have great pleasure in stating, that I have not, and that these gentlemen assure me they have not, any reason to believe or suspect that any of the plates executed by you for the bank of the United States or its branches, have been counterfeited.

I can only speak of the plates executed by you for the bank of the United States and its branches.

I am, very respectfully, yours, &c.

(Signed) L. Cheves.

Upon Perkins' first arrival in London he had sought, during the period of waiting on the Commissioners' pleasure, to introduce his fire engines to the London insurance com-

[117] The Bank of England notes have always remained a more or less simple affair, far more difficult to counterfeit than an elaborately engraved note. The Bank of England depends more upon its paper and watermarking than upon printing and design for the prevention of copying.

[118] Langdon Cheves, 1776-1857. He was an able lawyer, judge and statesman. In 1819 he was made president of the board of directors of the Second National Bank, which was by then in a state of almost complete bankruptcy. During the next three years of careful administration, he restored the bank's credit and was able to resign from its directorship in 1822.

panies. A letter written on September 31, 1819, to Bacon in Philadelphia, of which an extract is here given, reads: [119]

> Since our arrival in London there have been many fires, in one or two instances Mr. Perkins has had an opportunity of seeing the quality of the engines used here, and the distance the best will play, a first rate with picked hands will not exceed 150 feet, but most of them now in use will not play over 125 feet.
>
> The Insurance Coy of which Mr. Vaughan is Governor have ordered a first rate Engine and two supply pumps which will be commenced as soon as Mr. Perkins can spare the time. I have no doubt of their being brought into general use, particularly if two or three leading Insurance Offices adopt them & a factory established, which I doubt not will be the case in a few months
>
> J.W.C. for Perkins & Fairman.

William Vaughan the banker, who is referred to in this letter, was elected director of the Royal Exchange Assurance Corporation in 1783 and continued in it as director, Sub-Governor and Governor until 1829. He was a fellow of the Royal Society and an authority on the subject of wet docks for the Port of London.

At this period the various insurance companies in London maintained their own fire brigades to extinguish fires where possible in order to lessen their losses on insurance claims. At first the insurance companies worked independently of each other, but in 1825 the Sun, Union, and Royal Exchange and subsequently the Atlas and Phoenix, decided to pool their engines and equipment to the mutual benefit of all and soon some thirty to fifty manual pumpers were available at any fire in which the owner of the property involved was insured by one of the combine. It is not known how far Perkins' improved force pumps and fire engines were adopted in England, except as far as the foregoing letter indicates. He did however take out a British patent for "pumps" dated June 3, 1820, which covered their possible use for fire engines.

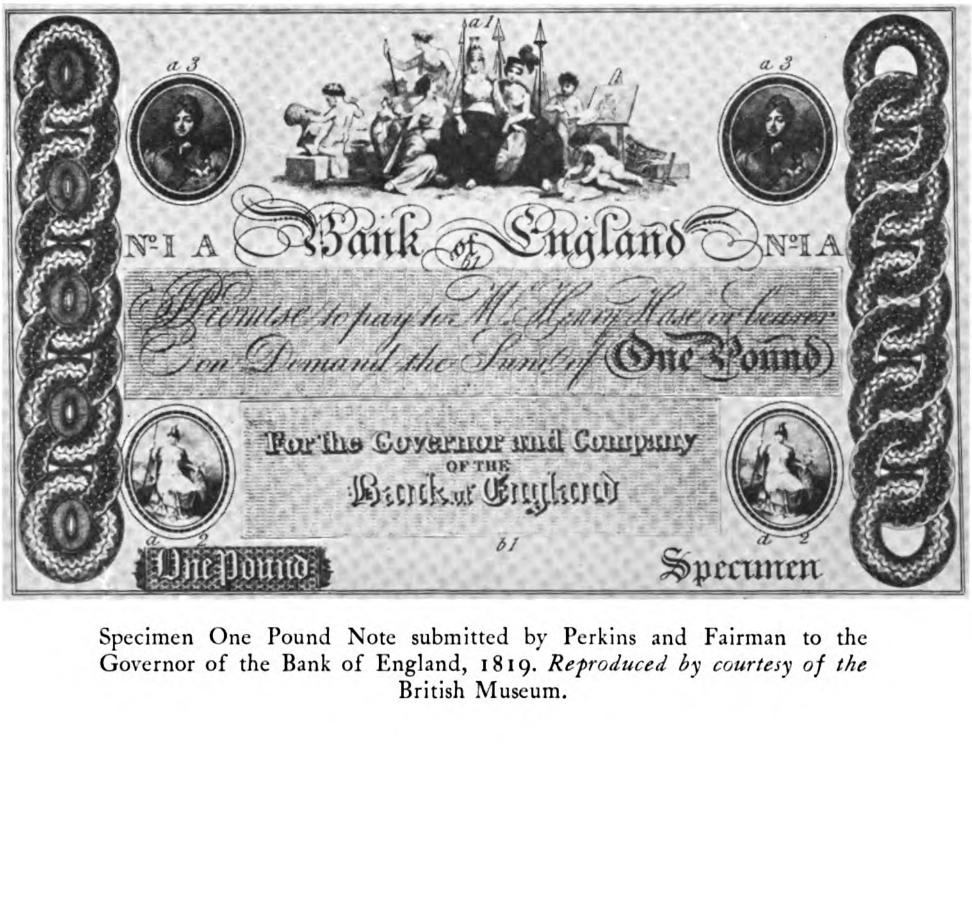
On April 18, 1820, an arrangement was made with Bryan Donkin[120] the engineer, to manufacture at his works in Blue Anchor Road, Bermondsey, one of Perkins' fire engines for the Royal Exchange Company. Donkin was at this time collaborating with Sir William Congreve to perfect a method of printing bank notes in two colors. Aside from the one instance mentioned there is no evidence that Donkin ever built any more of Perkins' engines or that any preference was given to them by the insurance companies, due perhaps to the conservatism of the times.

This may be gauged from the fact that many of the London companies, including the London Assurance, Royal Exchange and Phoenix Fire Company, continued until 1832 to use Richard Newsham's type of engine, which was first introduced in London in 1740. However, the Society of Arts did recognize Perkins' work in this direction with their silver

[119] From the personal papers of the late Mr. Loftus Patton Perkins, of London.

[120] Bryan Donkin, 1768-1855. The inventor and constructor of the first practical papermaking machinery, 1801-1810. At this time eighteen of his improved machines were at work and soon completely displaced hand-made paper. In 1813 he invented the polygonal printing machine, the first one of which was set up at Cambridge University. In 1819 he applied his talents to bank note paper and in this connection, Perkins' principal interest lay. Also at this time Donkin's pantograph engraving machine must have filled Perkins with some concern. This had been constructed in 1820 to facilitate Congreve's work at the Bank of England and Perkins may have had some misgivings that this might supplant the Asa Spencer lathe, in perfection of work for line engraving. The possibility of manufacturing Perkins' fire engines by Donkin at his well equipped engineering works apparently did not materialize into anything definite. Bryan Donkin was at one time vice-president of the Society of Arts and vice-president of the Institution of Civil Engineers and he was also a fellow of the Royal Society, and he served on its councils.

The Bank of England as it looked in Perkins' day. Erected in 1732, by the architect George Sampson. From *The Penny Magazine.*



Specimen One Pound Note submitted by Perkins and Fairman to the Governor of the Bank of England, 1819. *Reproduced by courtesy of the* British Museum.

medal in 1820 for introducing an improved method of fastening the seams of leather hose by copper rivets, and also for his drawing of a new swivel coupling that would not obstruct the flow of water.

The Society of Arts[121] honored Perkins' inventive talents in a marked degree, for they conferred upon him in 1820 and 1821 no less than five awards, three gold medals and two of silver. These are shown in obverse and reverse on Plate XXI. The first of these awards was for the improvements in riveting hose and making swivel couplings. Perkins submitted this to the Society December 22, 1819, and he was granted one of the first of the new large silver medals designed by William Wyon in 1820, on which Perkins' name was suitably engraved. The second award was the Society's large gold medal for the triangular valve pump for ships. This was submitted by Perkins on January 10, 1820. The third award was for his improvements to water wheels submitted March 8, 1820. For this Perkins received the Vulcan gold medal, designed in 1818 by George Mills, which was bestowed only for mechanical arts. The fourth award was the Society's large silver medal for a warming stove and a method of ventilating the holds of ships. These two inventions were brought before the Society by Perkins on March 28, 1820. The ventilator described was undoubtedly the same as that applied by Perkins on several of the American frigates during the War of 1812. Perkins by a further communication to the Society amplified the uses of his heater by showing the possibility of warming several rooms with the same stove. In connection with Perkins' system of warming by hot air, his plan was carried out on a large scale at the printing office of T. C. Hansard in the Old Bailey in the winter of 1819. The firm of Hansard had been the official printers of all the proceedings and debates in the House of Commons since 1744. The fifth award was another Vulcan gold medal for the ship's instruments, the orthometer and pleometer, submitted to the Society February 26, 1821. In Appendix G. will be found a complete description, with engravings, taken from the transactions of the Society of Arts, of the foregoing inventions and apparatus.

Of these several inventions, three models made by Perkins, were presented to the Society. These were the ships' pump, hose and coupling, and the navigating instruments, all of which were placed in their repository or museum room. A contemporary view of this room is shown on page 88. The Society's museum was dispersed in 1850 and most of the models went to the Museum of the Patent Office. These were again moved later on to the Science Museum in Kensington.

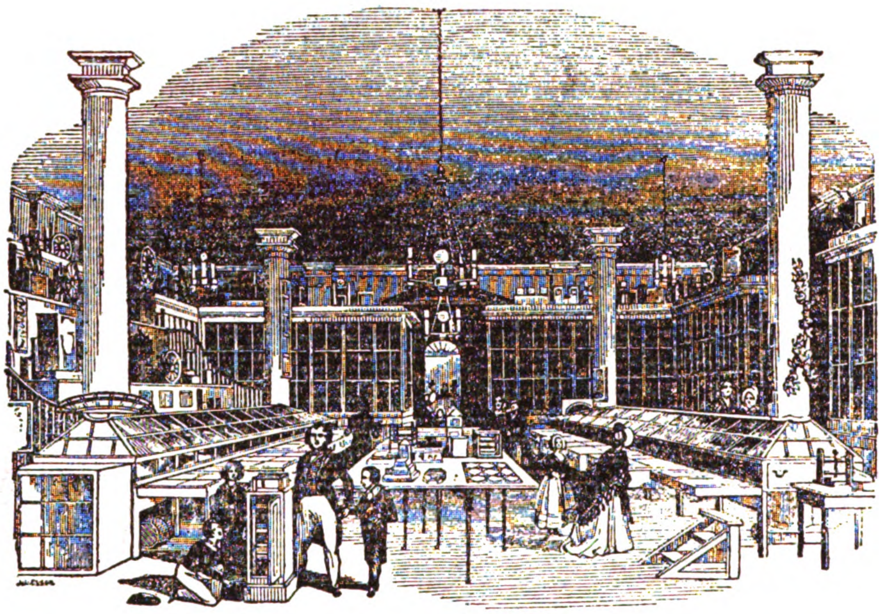
In line with other useful things which Perkins brought over with him from America, the following may be quoted from *The Technical Repository* of 1820: "It is said that Perkins introduced the twist auger into England but twist bits were better known and used in America than in England at this time. Perkins said that he had often bored for water with a twisted borer of his own invention." Though not in common use in England

---

[121] The Society for the Encouragement of Arts, Manufactures and Commerce, generally referred to as the Royal Society of Arts, was founded by William Shipley in 1754. It moved to its present location in John Street, Adelphi, in 1774. By 1762 its membership had numbered 2,500. The Society at a very early date (1758) gave awards for outstanding merit. At first, purses of ten to fifty guineas and later on, gold and silver medals were given. Artists received a silver palette with a sum of money in addition. The first public exhibition of paintings in England took place in 1760. Awards were also given to poor workmen, as well as to men highly placed in the scientific world. This is a feature of the society which so honorably distinguishes it from so many others. Perkins was a contributing member of the society from 1820 until 1838. Perkins' son, Angier March Perkins, was also a contributing member from 1822 until 1833.

by carpenters and others, the twist auger nevertheless was not new in 1820, it being the invention of Phineas Cook in 1770 and it is recorded that the Society of Arts awarded him thirty guineas for this idea. The auger that Perkins is said to have introduced was probably that of Ezra L'Hommedieu of Connecticut, patented in 1809. This tool was the first to have flat chisel cutting edges and a spiral twist which brought up the shavings in a continuous stream.

In the summer of 1820 Perkins, Fairman and Heath moved from Austin Friars to 69, Fleet Street. These new premises were on the south side of the street, a little east of Temple Bar[122] at the end of the Strand and west of Water Lane, which is now called



The Model Room of the Society of Arts, Adelphi, London, where Jacob Perkins' nautical instruments and other apparatus were displayed. Engraved by Jackson for Charles Knight's *London.*

Whitefriars Street. The building was of red brick and was three stories high, previously occupied by Parker's glass factory. A double window front was added at a later date. See Plate XLII. The members of the firm, quite reconciled to the disappointment over the Bank of England business, now turned to other engraving work, for which there was a wide field open to them, in the illustration of books and the reproduction of pictures for albums. There were also portraits and book plates and for this class of work the Perkins steel plates produced the finest artistic results. Perkins also prepared steel plates for mezzotint engraving which gave soft lines with burnished high lights. Perkins' plates were used for printing the views in Pinnock's *Catechism of British Geography* in 1820 and also for Wilson Lowry's *Planisphere of the Solar System* which he engraved in 1821.

[122] Temple Bar, built in 1672 by Christopher Wren, must have been a very familiar sight to Perkins as he passed through it to the Strand. This obstruction to the congested traffic passing through Fleet Street was removed only as late as 1879 and was re-erected at Theobald's Park, Cheshunt, in North London. Plate XXXIX.

From the *Boston Literary Gazette* of December 1820 was found the following reference to the firm of Perkins, Fairman and Heath:

> Already they have engaged to manufacture bank notes on their inimitable plan for several Yorkshire and other banks, and they are also preparing various engravings for popular books, as maps and views for Goldsmith's geography, frontispiece for Mavor's spelling book, and a solar system for Blair's preceptor, all of which will have proof impressions of their engravings, though tens of thousands are sold annually. Over and above the applications, they are making preparations to print on cotton dresses [123] of greater beauty than ever fabricated before. The perfection of their prints must so improve the public judgment, that coarse and inferior prints must soon be banished from use: and hence the arts themselves must be greatly improved.

At first steel plates for pictorial engraving were etched with nitric acid in the same manner hitherto employed for copper, but it was found that there was great difficulty in getting the acid to bite in deeply enough and the lines were very shallow and rough on the edges. Realizing this, many artists refused at first to work upon this new innovation of steel plates. Perkins also experienced this trouble and tried in many ways to overcome it by various combinations of acids. It is said that Perkins paid Lowry the engraver £50 for the secret of his menstruum.[124] Though not entirely satisfactory, Perkins had found that worn out acid from his copper plates, which formed a weak solution of copper nitrate, was the best so far. It was not until 1824 that Edmund Turrell invented his corrosive medium, combining with the nitric acid pyroligneous acid and alcohol. With this medium it became possible to produce clear deep lines on steel.

By far the largest as well as the most profitable work now engaged in by Perkins, Fairman and Heath was bank note engraving and printing and Perkins soon came to realize that the city and county banks of England alone would represent a tremendous source of revenue to the firm. At this time, 1820, almost anybody could start a country bank and hundreds of such banks at this period were doing business and printing their own paper money without any proper security behind their issues. The provincial bank notes were principally for one pound and it was in these low denominations that most of the forgeries were accomplished. The Act passed in 1820 to suppress the pound notes of the Bank of England and to compel them to pay small amounts in cash was repealed in 1822 and a new Act passed to enable pound notes to be again circulated. This was in force for more than ten years and enabled all banks, both city and provincial, to expand their paper issues beyond belief. Between 1824 and 1825 this increase amounted to as much as 40 per cent.[125] It may

[123] Calico printing up to this time, and long afterward, was performed by applying individually patterned wood blocks by hand. Engraved copper plates had also been tried but these tiresome methods finally gave way to the cylinder printing machine, first tried in a crude way in 1785 at Monsey, Scotland, by Bell and Hargraves. It may be presumed from this reference that cotton and other fabrics were to be printed from Perkins' engraved plates, but there is nothing to indicate that this was done to any extent until the expiration of the patent in 1833, after which the system was gradually adopted of indenting the copper cylinders of calico printing machines from hardened steel rollers made from a master steel plate engraved with the required flowers, sprigs or other designs. The cost of engraving the copper cylinders 30 to 40 inches long by hand was about £50 but the cost was only some £7 when Perkins' method was employed which consisted of using small transfer rollers with a single design that could be reproduced indefinitely.

[124] Wilson Lowry, 1762-1824, was an engraver of architecture and mechanism. He engraved many of the plates for Rees's *Cyclopaedia*, which was his principal occupation for twenty years. Lowry was the first to use a diamond point for ruling and the first to discover a satisfactory method of etching steel plates.

[125] "Sedgwick's Tables," *Edinburgh Review*, 1826.

therefore be gauged to what a rosy business future Perkins could have looked forward to had he but applied himself strictly to this line of work.

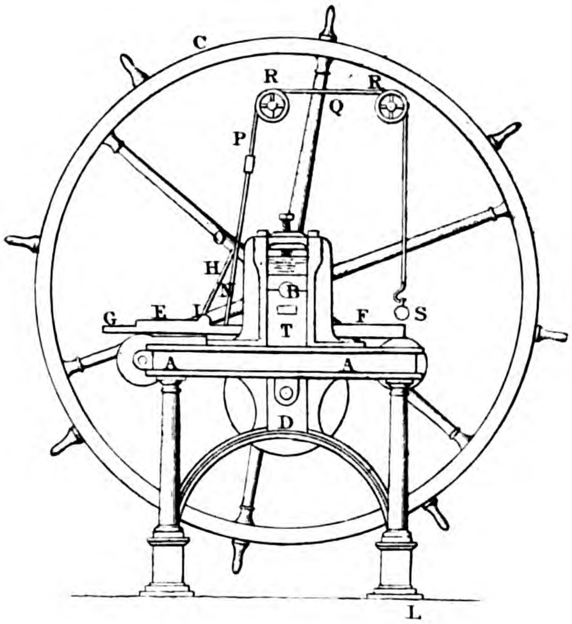
In 1821 the firm of Perkins, Fairman and Heath obtained a contract to supply their engraved plates for printing the new issues of paper money for the Bank of Ireland,[126] whose capital had just been increased by £500,000. At this time the head of the department of engraving and printing was John Oldham of Dublin, one of the ablest mechanicians of his day. He was the inventor of a mechanical system for consecutive numbering of bank notes, which was afterwards also adopted by the Bank of England and all railway companies. Oldham was also the inventor of a feathering paddle wheel which he had patented in 1817. Oldham had seen specimens of Perkins' and Fairman's engraving in Liverpool while Perkins and his party were staying there prior to their departure for London, and was most favorably impressed with their work as well as with the business enthusiasm displayed by the Americans. When Oldham returned to Dublin and handed his report to the directors of the bank, unprejudiced as it was by the side issues of nationality, it did much to influence the bank in making their decision to adopt the Perkins method of engraving. It was now deemed necessary as a matter of business by Perkins to have his son-in-law, Joshua B. Bacon, come over from Philadelphia and enter the London firm, and assume the financial management. The fire engine factory in Philadelphia, hitherto under the management of Bacon, was then taken over by Samuel Vaughan Merrick in 1821 and as far as Perkins was concerned, his interest in it ceased. A small eight page price list, illustrating the fire engines (Plate XV), issued this year by Merrick, stated that he was now owner of the business. The title page of his catalogue reads: [127]

> A Description of the Patent Improved Fire Engines and other Hydraulic Machines invented by Jacob Perkins and manufactured by S. V. Merrick and Company, successors to Perkins and Bacon, at the factory back of St. James Church North Seventh Street Philadelphia.

Farther on in this catalogue it is stated that three hundred engines have already been made of various sizes, which were then in use in Philadelphia, and different parts of the United States and the West Indies. The prices and range of the fire engines offered by S. V. Merrick & Company varied somewhat from those of Perkins & Jones, as the following items taken from Merrick's catalogue will indicate:

Domestic Engine in Oval Tub	\$42 to \$47
Large Size for Use on Board Ships	\$65 to \$100
Village Engines, will play over 4 storey house with less than 8 men	\$225
Village Engine, first class, requires 8 to 12 men	\$275
Second class City Engines, require 20 men	\$450
First class City Engines, require 30 men & will discharge ¾ of a ton of water per minute	\$650

126 The Bank of Ireland was established by Act of Parliament in 1782 and the bank's charter dates from May 15, 1783. The capital was £600,000, lent to the Government at 4% interest, no individual subscription was to exceed £10,000. In 1821 the capital was increased from £2,500,000 to £3,000,000. The bank was at first located at St. Mary's Abbey, Dublin, but in 1808 the bank was removed to the old Parliament House in College Green. The Provincial Bank of Ireland came into operation January 5, 1826, to give greater facilities for country banking. It rapidly advanced in prosperity as the trade and commerce of the country became more stabilized and the introduction of a regular service of steamboats (The City of Dublin Steam Packet Company) gave a new stimulus to business between England and Ireland.
127 Copy in The Philadelphia Library Company.

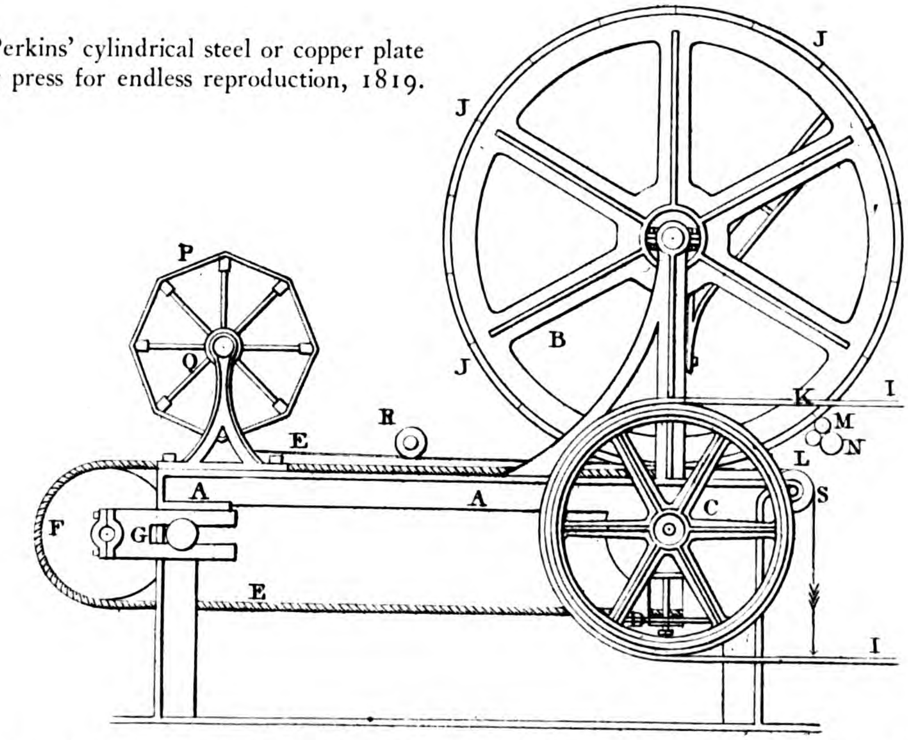


Jacob Perkins' and George Murray's copper plate printing press for single copies, 1813.

AA—The cast iron table and frame.
B —A cast iron roller turned by the capstan wheel C.
D —The lower roller.
EF—The bed of the press.
G —The plate or printing block.
H —The tympan, hinged at I, with an aperture the size of the block which prevents the edges of the paper from being soiled.
N —The blanket holder, stretched by the cord P, passing over the pulleys RR by the weight S.
T —The packing pieces under the bearing of the roller B.

The table of the press slides on three rollers as shown, and to facilitate the quick return of the plate for inking, a portion of the roller B is removed. This is known as the **D** roller press as originally invented by Perkins.

Jacob Perkins' cylindrical steel or copper plate printing press for endless reproduction, 1819.



AA—The cast iron table of the Press. B—The main cylinder to which the printing plates JJJ are fixed by screws. C—The lower cylinder or roller that gives the required pressure and motion to cylinder B. D—One of the adjusting screws. E—The endless web or blanket. F—The idler pulley and the adjustable bearing G. K—The inking roller for the plates J. MN—The distributing ink rollers. P—The reel on which the endless sheet of paper is wound. R—The ductor roller to guide the paper. S—The roller over which the sheets pass after printing. This form of press, driven by a steam engine, was used principally for producing bank notes.
From Barlow's *Manufactures and Machinery of Great Britain.*

Toward the end of December, 1821 Bacon and his family arrived in London and he immediately joined the firm of Perkins, Fairman and Heath as their business manager, and under his able care the prestige of the concern was greatly increased. Of the sacrifice of the fire engine manufactory due to the hurried departure of Bacon for England, little comment is needed. It is enough to say that on this promising foundation, Samuel V. Merrick built a magnificent engineering business which was carried on successfully by his sons later as the Southwark Foundry Company, located at 430 Washington Street in Philadelphia.

Perkins with each passing month in London was becoming more and more committed to the many interests, both business and social, which claimed his attention and it is fairly certain that by 1821 he was reconciled to remaining in England indefinitely. He yearned, however, to see his family and to settle himself in a home of his own. Also his second son, Angier March, was at an age when a place could be found for him in the engraving business. This seemed all the more necessary by now, owing to the increasingly poor health of the elder son, Ebenezer. Perkins therefore wrote to his family in Newburyport, instructing Angier March to bring his mother and three sisters to London. Of this event Angier March Perkins himself said: [128]

> We embarked on board the ship "Electra" 500 tons, Captain Robinson, about November 1821 and arrived in England in thirty days, where we found my father and brother and all our friends. I was twenty one years of age and went at once into the employment of my father and his partners and was engaged for the next eight years in manufacturing banknotes, dies and plates. During the latter part of the time I taught other parties to do the work I was engaged upon and my services in the firm became unnecessary and I found myself obliged to obtain other business.

Upon the arrival in London of Perkins' wife and family, the upper rooms of the commodious premises on Fleet Street began to assume a homelike air and Perkins was able to enter more fully into the social life which eddied around him. It seems safe to say that Perkins and his family resided here for many years, probably up until 1831 when Angier March Perkins married and Jacob Perkins retired from active business pursuits.

Though Perkins' creative abilities were primarily conducted along the physical lines of mechanics, his natural curiosity often directed his attention to things which pertained to pure science. In this field, though not in any way qualified by previous training, he nevertheless often excelled. His experiments to determine the compressibility of water in 1819 and later in 1822 on the liquefaction of air, should rank him as a physicist of high order. That this was never done would seem to have been an act of neglect which still might be remedied.

Perkins' first experiments on the compressibility of water, conducted in Philadelphia in 1818 and 1819 and also during his voyage to England, might have entirely been ignored but for the interest taken in the matter by Sir Joseph Banks, then president of the Royal Society in London. Sir Joseph had first met Perkins during sessions of the Crown Committee and had offered to introduce a paper on the subject of Perkins' experiments at a meeting of the Royal Society in the near future. Unfortunately, Sir Joseph Banks died on June 19, 1820, and the paper was read on June 29th by proxy. Nevertheless it created a great stir in the scientific world and Perkins received the flattering congratulations of the members of the Royal Society. Something of this is to be found in a letter dated

[128] From notes written by A. M. Perkins in 1877, then in the possession of the late Mr. Loftus Patton Perkins.

January 15, 1821, written by Petty Vaughan from London to Dr. Edward Everett [129] in Cambridge, Massachusetts, in which he said:[130]

> The scientific world has lately been much interested in the successful experiment of our ingenious friend, Mr. Perkins, in compressing water, which he has done to the entire satisfaction of Dr. Wollaston and others, to the amount of 3 p. ct. An account of it will appear in the next vol. of the Philo. trans— indeed his talents in many other points have excited the admiration of all who have had an opportunity of witnessing them, and with his liberality and amiable condescension in communicating his views to others, have been noticed in many of the Periodical works of this Kingdom.

Perkins' paper *On the Compressibility of Water* was published in the transactions of the Royal Society for 1821 and is too long to be reproduced in full here but an abridged reading is necessary to fully grasp the nature of his discoveries. Dr. William Hyde Wollaston[131] particularly interested himself in Perkins' experiments and suggested the form of apparatus that should be used to further them. The results of these further tests with water and also on the liquefaction of gases were read before the Royal Society in 1826 and will be referred to more fully later on. Of Perkins' experiments on water he himself says: [132]

> First experiments conducted with a 12 lb. cannon fig. 2 in America in 1819. The Piezometer used fig. 1—is a cylinder A 3 inches in diameter x 18 inches long closed by a cap B. A rod 5/16″ diameter passed through a stuffing box, a flexible ring to slide on the rod is used to mark the passage of the rod. The Piezometer is placed inside the cannon which was sank into the ground leaving 18 inches exposed. A screw cap A closes the muzzel, in the center of the cap is screwed a small faucet pump with a piston 5/8″ diameter. The aperture C is for ascertaining the pressure by means of a lever and a weight of one pound equal to one atmosphere required to lift the valve. By moving the weight further from the fulcrum a greater amount of pressure is retained in the cannon. The Piezometer being completely filled with water a pressure equal to 100 atmospheres was pumped into the cannon. On removing the cap and examining the rod of the Piezometer it was found to have sunk 8 inches showing a compression of water equal to 1%. By repeated experiments it was found 3% of water could be pumped into the cannon. These experiments were continued during the voyage from America to England as previously described but in this case the pressure of the water of the ocean at extreme depths took the place of the force pump.

The important discovery that gases could be liquefied has generally been conceded to Michael Faraday,[133] in 1823, when, during some experiments with chlorine gas at the

---

[129] Dr. Edward Everett, 1794-1865, Unitarian clergyman, teacher and statesman. Graduated from Harvard in 1811, awarded a Ph.D. at Gottingen in 1817, the first ever to be given to an American. In 1820 he became editor of the *North American Review* which was founded by Joseph C. Dyer and William Tudor the American author in 1815. Everett served five years in Congress, was Governor of Massachusetts in 1835 and Minister to the Court of St. James during 1841 and 1845. Petty Vaughan, his correspondent, is believed to have been a brother of John Apthorp Vaughan, of Massachusetts, and a nephew of William Vaughan, the London banker.

[130] The Edward Everett papers, Massachusetts Historical Society.

[131] Dr. William Hyde Wollaston, 1766-1828. Celebrated Physicist. His experimental research was principally along the lines of optics and electricity.

[132] "On the Compressibility of Water" by Jacob Perkins of 29 Austin Friars. From the Philosophical Transactions of the Royal Society, London, of 1821, pp. 324-329, with an engraving of the apparatus. (Refer to Plate XVI.)

[133] Michael Faraday, 1791-1866, chemist and physicist. In 1813 he was appointed assistant in the laboratory of the Royal Institution on the recommendation of Sir Humphry Davy. By 1825 Faraday was director of the laboratory and Fullerian professor in 1833.

The Gold and Silver Medals awarded to Jacob Perkins by The Society of Arts, in London, during 1820-1821.

Reproduced through the courtesy of Baker, Perkins, Ltd., of Peterborough, England.

instance of Sir Humphry Davy,[134] this phenomenon was observed by these two scientists. Perkins, whose previous high pressure experiments with water, as well as his specially constructed apparatus, which eminently fitted him for this field of research, appears by a statement before the Royal Society to have made this discovery even earlier. In his second paper read before that body in 1826, he stated he was successful in liquefying air in January of 1822.

A strong substantiation of this claim is to be found in an editorial notice by Richard Phillips in his *Annals of Philosophy* of July 1823, which says:

> A paper on the compressibility of water, air, and other fluids, and the liquification of aeriform fluids by simple pressure, was prepared by Mr. Perkins for the purpose of submitting it to the Royal Society; but it was accidently misplaced previously to the last meeting, and therefore could not be announced to the Society with the other papers. It contained, we are informed, a minute description, accompanied with figures, of his compressing apparatus, a diagram, showing the ratio of compressibility of water, beginning at the pressure of 10 atmospheres and proceeding regularly to that of 2000; and some experiments on the compression of atmospheric air, which appears by them to follow a law varying from that generally assigned to it by philosophers. Mr. Perkins intended to announce also, in this paper, that he had effected the liquification of atmospheric air and other gaseous substances by a pressure equal to that of about 1100 atmospheres and that he had succeeded in crystallizing several liquids by simple pressure.

This paper, submitted to the Royal Society, was never published and its whereabouts is unknown. An unfortunate happening for Perkins. But for this his claim to being the first to liquefy air and other gases might stand fully recognized.

Faraday's discovery of this peculiarity of gases to liquefy under pressure seems to have been a pure accident. In the spring of 1823, during some experiments with hydrate of chlorine in the laboratory of the Royal Institution, it was suggested by Sir Humphry Davy that he try heating the hydrate under pressure in a sealed glass tube. After fusing the tube became filled with a yellow gas and the tube also contained an oily liquid. When the end of the tube was broken off, an explosion occurred and the oil vanished. This oil turned out to be liquid chlorine which on being relieved of pressure in the sealed tube, returned to a gaseous state. "Faraday afterwards liquefied chlorine by a compressing syringe and succeeded in reducing a number of other gases up to that time deemed impermanent to the liquid condition." [135]

So important were these discoveries considered that Sir Humphry Davy read two papers on them before the Royal Society on *The Condensation of Gases,* based on the experiments of Faraday. But what of Perkins' previous work and discoveries in this field?

As far as the attitude of the Royal Society was concerned, they were under no obligation to especially recognize the independent discoveries of others. Perkins was not a member of the body nor was he a recognized scientist. It was to be expected under these circumstances that Sir Humphry Davy, as president of the Royal Society, did not particularly wish to have a comparative newcomer usurping any of his prerogatives as the acknowledged director of British science. From Perkins' standpoint, he was at the time undoubtedly more interested in the concrete results of his experiments than in acquiring any permanent fame. His friendly

[134] Sir Humphry Davy, 1778-1829. Was at this time president of the Royal Society, being elected on November 20, 1820.

[135] From the account given in the *Dictionary of National Biography*, London, 1889.

relations with Faraday, as well as many other members of the Royal Society, are well known. Whatever failings Perkins may have had, his unselfish desire to share his discoveries with others was proverbial and from this angle, perhaps, is to be found the answer as to why his individual scientific work has so long been overlooked.

Though Perkins never became a member of the Royal Society, nevertheless he seems to have maintained some connection with that body through the friendly interests of Dr. Wollaston until the latter's death in 1828. Perkins became a member of the Institution of Civil Engineers at the time of its charter in June of 1828, but during his membership in this body he did not take any prominent part in its proceedings. He contributed, as far as can be determined, three papers on the Steam Engine, and a paper on February 7, 1837, on locomotive practice and the necessity of standardization of parts. In addition to his affiliations with two American societies in Boston and Philadelphia, Perkins was a corresponding member for many years of the Philosophical Society of Manchester, this being due no doubt to the influence of Dyer at the time of Perkins' first arrival on English soil in 1819. It may well seem that Perkins, though extremely social, pleasant of address and generally respected, which he undoubtedly was, did not find much outlet for his talents through scientific bodies, preferring rather to address himself more directly to the public ear.

In this aspect we find Perkins, in 1822, appearing before a Select Committee of the House of Commons to give his opinion on matters of steam navigation in connection with the steam packet service between Great Britain and Ireland. This particular session was held on June 12th and a "long and desultory conversation is reported to have taken place with the engineers Messrs. Bramah, Donkin, Brunel, Galloway, and Perkins whose opinions varied as to size, strength, materials most proper and the best construction of boilers." At this gathering "Mr. Galloway and Mr. Perkins said they felt confident that high pressure boilers may be so contrived as to be used with the greatest advantage." After this oracular but not very enlightening remark, Perkins continued in answer to further queries and gave such strong evidence in favor of high pressure boilers "from actual use of them in 150 American Steam-boats as to go far towards removing the prevailing objection to them."

At this time the coastal steamboats were still quite small affairs, averaging from 150 to 300 tons, and the engines were almost without exception on the low pressure principle, but in spite of their deficiencies they made fast time compared with the sailing packets. The voyage by sail from Liverpool to Dublin, a distance of 131 miles, required an average of 36 hours, while by steamboat only 14 hours, and from London to Dublin, a distance of 610 miles, occupied a sailing vessel 16 days, while by steam the trip consumed only a matter of 3½ days.

In July of 1822 Gideon Fairman decided to return to Philadelphia. His associations in London had not been altogether satisfactory to him and it is evident that he was not in accord with the business set-up of the London firm. Also, perhaps, he suffered from that most common of all ailments which afflict a stranger in a strange land, homesickness. He no doubt missed the familiar surroundings and the more even tempo of Philadelphia. Fairman arrived back a few scant weeks too late to see again his venerable partner, George Murray, who had died on July 2nd of that year. Murray's death involved a reorganization of the firm and a notice in the *General Advertiser* of November 11, 1822, states that:

> The surviving partners, jointly with Mr. Asa Spencer, will continue to carry on the Engraving and Printing of Bank Notes, under the firm of Fairman, Draper, Underwood & Co. and from the

arrangements that have been made, they will be enabled to execute the work in a manner superior to any they have heretofore done.

It must have obviously transpired by now that Perkins was by nature incapable of prolonged effort along any business lines which did not provide him with the excitement of new discoveries. By 1822 the engraving business in Fleet Street was progressing along most profitable lines under the capable management of his son-in-law, Joshua Butters Bacon and the skilled co-operation of his assistants, among whom were Charles Toppan, Asa Spencer and his own son, Angier March. With things running smoothly in this quarter Perkins now felt he could at last devote his attention to a matter which had been seething in his mind for a long time and he began to take definite action with an intriguing problem. This was one which must have often been a subject of discussion between himself and Oliver Evans in Philadelphia, namely, how much more power and economy of fuel could be gained for the steam engine by using still higher pressures, earlier cut-off and greater expansion of the steam, all of which tended to materially reduce the dimensions and the cost of the machinery. Perkins while in Philadelphia had had every opportunity of noting the more glaring defects of the high pressure system which was at that time new and in careless and incompetent hands, highly dangerous. Perkins on page 3 of his treatise *The Concentrating Steam Engine*, speaks of his original plans toward improving the high pressure engine as it stood at that period: "My first intention was to follow up Mr. Evans's ideas of high pressure, and to do what the want of a metallic piston etc. prevented him from doing; viz—using steam of greater expansive force." But later on Perkins reasoned that only by a radical divergence from the usual design, either in the method of generating the steam or in the shape of the boiler, or else in some essential addition or alteration to the engine itself, could any further improvement in efficiency be hoped for. His earlier modest desire to develop the steam engine soon gave way to expressions of imponderable theories, the value of which during the ensuing eight years was to be but partially proved by practice and wholly unproductive from the standpoint of profit to the inventor or to his associates. Nevertheless, as the account of this strenuous period of Perkins' life is unfolded, it will be seen that his inability to turn current opinion, both private and professional, toward new horizons of steam engine progress was due rather to overshooting his mark than to failure to reach it. The extravagant claims as to the possibilities of his discovery did more to harm his cause than the honest difficulties he encountered in the practical working out of his invention. Later on in the century, others took up the problems where Perkins left off, or it may better be said gave up, but most of these later improvers forgot, with the passing of time, to acknowledge the pioneer who had already broken so much hard ground for their benefit.

Perhaps it would be unfair to say that Jacob Perkins made any definite bid for public acclaim, but nevertheless he was quite carried away by the excitement and interest which he was creating in London at this time. For ever since his dramatic arrival from America to win a great prize from the Bank of England, and his frustration which had aroused the most sympathetic interest, he had been very much in the public eye. He had assumed a position in the society of the day and in scientific circles, both with an easy grace, and the promise of his further inventive genius made him a man on whom to speculate. Perkins' opinions were deferred to by scientists and engineers, his pronouncements were quoted in the newspapers and periodicals of the day, he was showered with medals for achievement,

and great artists painted him in dignified poses. It is but little wonder that Perkins sometimes lost a portion of his true perspective in his efforts to live up to all of this. There are so few letters in existence written by Perkins at this period of his life, that the following is thought worthy of introduction here. This letter was addressed to Dawson Turner, of Yarmouth, and is postmarked 1823: [136]

Dawson Turner, Esqr.
Dear Sir:

When your letter of the 17th arrived, I was in Manchester, and since my return I have been extremely occupied or I should have answered it long before. The flattering manner in which you are pleased to speak of me, creates in my bosom the most lively emotion and adds another motive for making me proud of being a descendant from English Grand-parents. That Mrs. Turner should have thought me worthy of devoting so much of her valuable time and extraordinary talents, is quite as surprising as what she has effected. My friends join with me in praising the execution of the etching and likeness. It has been observed that one eye is too small. I would not have asked for so large a number as fifty copies, were it not that I wish to show to my American friends what an English lady is able and willing to do. When Mrs. T. and yourself visit London, I hope you will allow me the honor of personally thanking you for this marked attention, to a not long since perfect stranger. That I may be enrolled as one of your friends is the proudest wish of my heart.

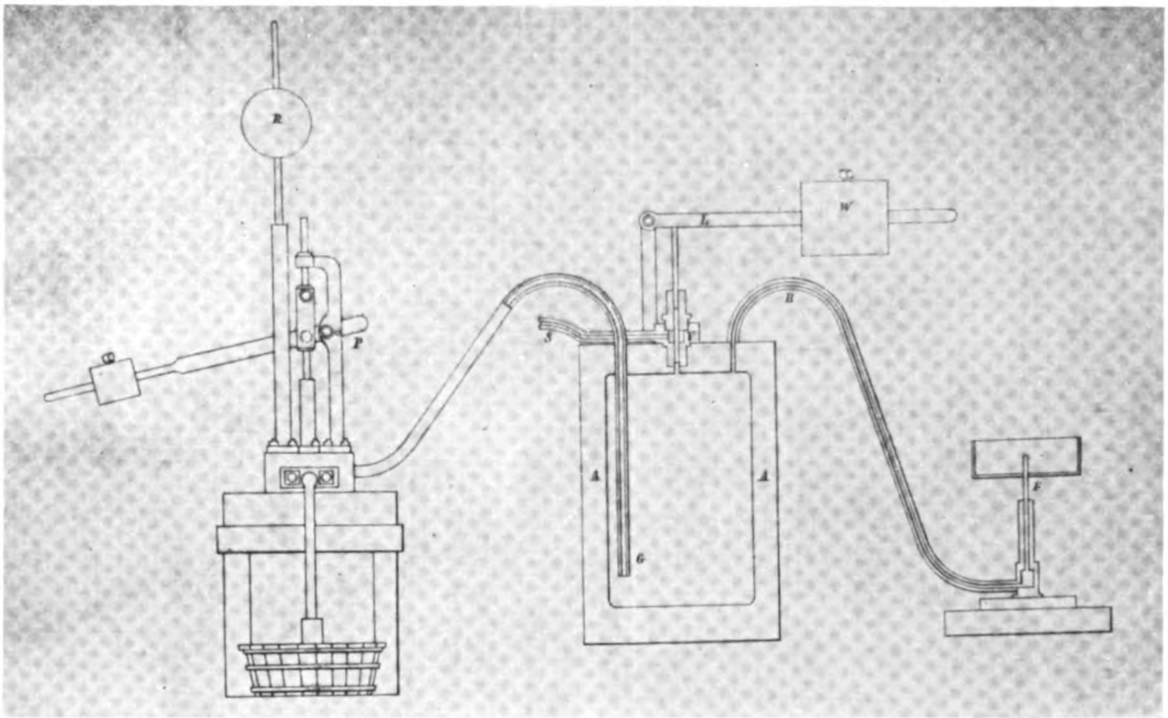
I am most respectfully,
Your humble servt.
Jacob Perkins.

While one must make every allowance for the rather stilted language of the times, nevertheless Perkins' letter to Dawson Turner[137] is, to say the least, flowery and shows a subtle metamorphosis from the Perkins of an earlier and sturdier day.

In all, Perkins obtained seven British patents for improvements relative to steam engines and boilers. These were exclusive of the patent for discharging projectiles by the force of steam. The first of these patents is dated June 10, 1822, and may be simply described as a method of preheating water in a closed vessel of great strength, to such a high temperature that, upon releasing this confined water by means of a loaded valve, it would instantly turn into steam. The original drawing from this patent, No. 4732, is reproduced on Plate XXII. The upper drawing represents the system employed for generating the steam. To the left facing is the force pump P, discharging through the loaded non-return valve into the supply pipe G, in the generator AA of great thickness and enclosed in a coal furnace. The pipe B connects the generator with the loaded pressure gauge F. The valve V, with its lever and weight LW, prevents the highly heated water from passing into the pipe S, leading to the steam engine. The action is as follows: a stroke of the pump which is driven by the engine forces a drop of water into the generator already full to capacity and the equivalent drop of water is displaced through the loaded valve V and flashes into steam as it is relieved of some of its pressure and some of its heat. Undoubt-

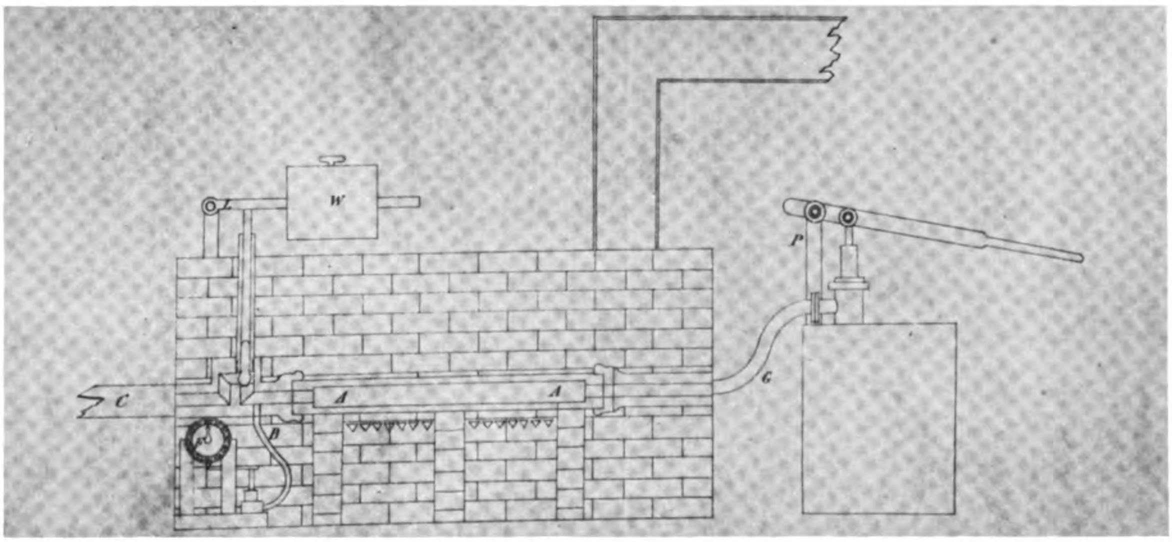
[136] Taylor Collection of the American Antiquarian Society.
[137] Dawson Turner, 1775-1858. Was born at Great Yarmouth, Norfolk. The eldest surviving son of James Turner, head of the Yarmouth Bank. Dawson Turner was celebrated for his scientific studies in botany and was the author of several elaborate works on this subject. From 1820 he devoted himself mainly to antiquities on which subject he wrote and published prolifically. His wife, Mary, was a daughter of William Palgrave of Coltis Hall, Norfolk. Mrs. Turner was a pupil of John Sell Cotman, the water color artist. Perkins' acquaintanceship with the Turners undoubtedly commenced with his work for the Yarmouth Bank, during 1822.

Jacob Perkins' Original Patent of 1822, for a New Method of Generating Steam.



AA—The gun metal generator heated by a furnace.
P —The supply pump.
R —A loaded non-return valve, on the water pipe G.
V —The steam valve held down onto its seat by the lever L and the weight W.
S —The steam pipe to the engine.
F —A deadweight pressure gauge.
The action is described in the text.

Jacob Perkins' Method of Heating Existing Low Pressure Boilers with Steam.



AA —The generator chamber, heated by a furnace.
P —The supply pump to force water into one end of the generator through the pipe G.
LW—The loaded steam valve.
C —The steam pipe leading to an existing boiler.
F —The pressure indicator supplied by the Pipe B.
The action is described in the text.

From a copy obtained through the Patent Office Library, London.

edly this form of steam boiler was infinitely safer than those of great capacity, for there is no live steam under confinement except in the supply pipe to the engine.

Steam of high pressure, produced as required by flashing it from a tiny particle of water,[138] has intrigued the minds of engineers ever since the steam engine cut loose from atmospheric pressure as a necessary running mate in the production of power as exemplified by the Newcomen and Watt engines. At the time Perkins put forward his ideas of flash steam in 1822, it would be safe to say that here was something so new and apparently so feasible that almost without further preparation or experiment, the steam engine was expected to grow up into a giant of power overnight. It has taken a hundred years of effort as recorded in engineering history to show the fallacy of that hope.

In the Perkins specifications, No. 4732, on the first page there is this statement: "Certain improvements in steam engines of which I am in possession in consequence of communications made to me by a certain foreigner residing abroad and of discoveries by myself." Now, in the light of this frank admission by Perkins that his invention for instantaneously generating steam was at least in part due to another, it is only just to try to determine who this earlier inventor was. It could not, of course, have been Oliver Evans because he had died in 1819; besides, except for his theoretical views on the possibility of a volcanic steam engine, Evans appears to have been fairly conventional in his practical thermodynamics. The only other inventor of record along these lines appears to have been the American, Joseph Hawkins, whose patent for a flash steam generator is dated June 14, 1816. Joseph Hawkins was said to have been blind or almost so at this period. He was a resident of New York and his patent claims were based on actual experiments conducted the year before he obtained his patent. In February of 1824 Hawkins and Anthony Plantou, his moneyed partner, demonstrated their flash steam machinery at a grist mill newly erected on the site of the old Mars Works, the engineering establishment of the late Oliver Evans in Philadelphia. Hawkins used a small cylinder of wrought iron, surrounded by a furnace, and cold water in a fine spray was injected, first by a hand pump to start the engine, after which the engine performed its proper sequence of operations automatically. The engine was of four horsepower and its useful performance was publicly certified by Rush and Muhlenberg, engineers, Oliver Evans, Jr., and others in April, 1824.

Possibly this may have been the source of Perkins' invention, or at least the inspiration for it seems to have emanated from America. The current opinion of some of his own countrymen was that Hawkins was the father of Perkins' invention, and statements to this effect appeared several times in the Philadelphia newspapers of the period, one under

[138] The expression "flashes into steam" is to be considered as merely an elementary explanation of what is apparent to the senses. Practical investigation had been going on for two hundred years to determine just what takes place when heat is applied to water and steam is produced. James Watt was the first to probe into the subject with mathematical precision. First in 1764 with his experiments on the latent heat of steam when applied to water and again in 1774 when he made comparative tables on the elastic force of steam in relation to its temperature. But these experiments were not carried beyond 15 pounds pressure. The properties of steam in Perkins' day were still a matter of individual opinion and all too often were not founded on any scientific investigation but were merely suppositions based on some observed phenomenon. Perkins' explanation of his principle of generating steam was "substituting pressure for surface," that is, water kept in close contact with the sides of the boiler by incompressible force is more effective than water under a lower pressure which can be easily driven away from the heated metal by the bubbles of steam. This was his theory and practice of 1822 but he found that beyond a certain point the heat applied to his generator did not correspond to a proportional increase of steam pressure but only tended to vastly increase its temperature to the detriment of the working parts of his engine.

the title *Steam Engine without Boilers,* says in part,[139] "without the enterprise of Mr. Perkins and the enthusiasm he has created in Europe, Mr. Hawkins would perhaps never have enjoyed the fruit of his discovery."

Toward the end of 1822, probably in November, Perkins took over the premises at No. 41 Water Lane. As it will be observed (Map 6), this street with its narrow entrance opening into Fleet Street runs due south to the foot of White Friars Dock on the Thames.[140] These premises, which were part of an old smithy, backed onto the rear of the engraving plant on Fleet Street and may possibly have had a direct communication between the two buildings. The first experimental engine was probably put under steam there during the last week of April of 1823. This is borne out by a letter written by Joshua Field,[141] the engineer, to Simon Goodrich [142] describing his visit to Water Lane. This letter is dated May 6, 1823:

> I have had frequent invitations from Mr. P. and saw the engine while preparing but until last week I have not seen it at work. I there joined a party consisting of Mr. Donkin, two Mr. Bramahs & Mr. Ostul having given 5 or 6 days notice of our intention stating to him that the motive of our visit was to satisfy our friends and correspondents who were pressing us with inquiries as to the reality of his discoveries. We were politely received and found the engine at work but to our surprise no resistence was prepared nor did we find that any had been applied so that all we saw was a small high pressure engine 2 ins. cylinder 12 ins. stroke working a 4 ft. fly wheel abt, 80 strokes per minute. I wished to press a wood lever against the wheel but he refused to let me do it.

Field continues indignantly, though with some justification:

> really we felt ourselves almost insulted by the manner in which he attempted to force the thing upon us without giving us the slightest evidence (as to the power or fuel) of the superiority or even equality of his engine with others.

The type of engine is shown on Plate XXIII and was rated by Perkins as of 10 horsepower and occupied a space of 6 to 8 feet. The cylinder was double acting and a rotary valve similar to those used on the Oliver Evans engines was used to distribute the steam.[143] The boiler on this first engine was 12 inches in diameter on the inside, of gunmetal, with walls 2½ inches thick. Each of the ends was flat and 3 inches thick and as it stood on end, was 22 inches high. It was surrounded by a firebrick casing and bellows were used to urge the fire. In fact the first experiments with the generator were carried out by placing the gunmetal cylinder directly into the heart of the blacksmith's forge. The maximum pressure obtained in this first generator was about 500 pounds, at which pressure Perkins

139 *Aurora and General Advertiser* of February 10, 1824.

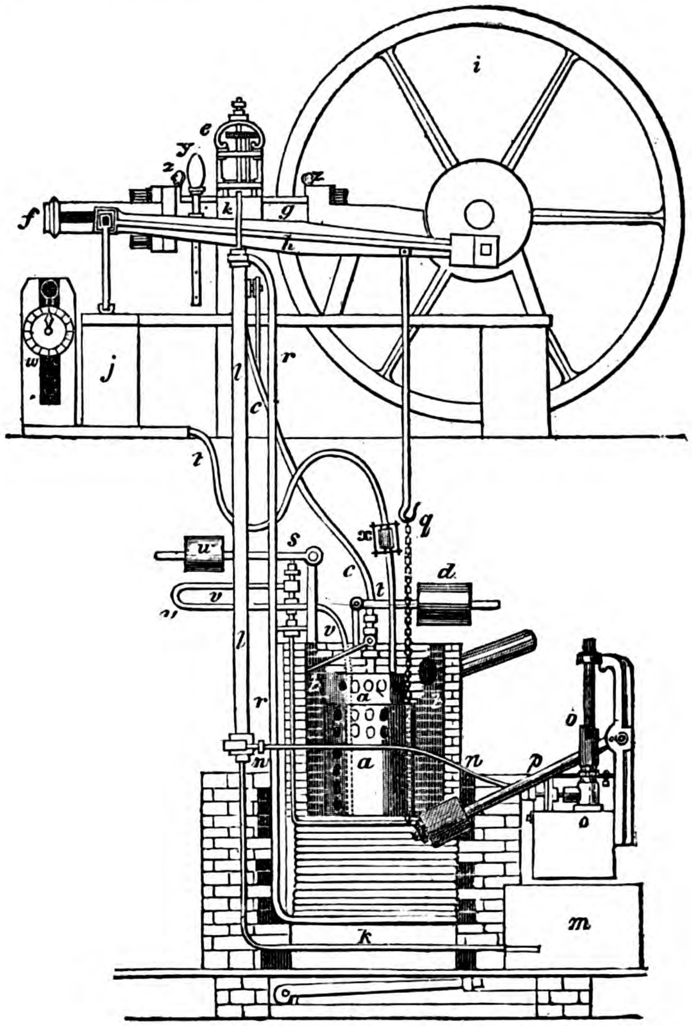
140 The name of Water Lane was later changed in 1844 to Whitefriars Street and now extends only from Fleet Street to Tudor Street. The muddy strand of the Thames which washed the foot of old Water Lane was reclaimed in 1864-1870 by building the Victoria Embankment.

141 Joshua Field, 1787-1863, the celebrated marine engine designer and constructor. At this time, Field was a partner in the firm of Maudslay, Son and Field of Lambeth.

142 Simon Goodrich, 1773-1847, at this time he was engineer and machinist to the Navy Board with residence at the Portsmouth Dockyards. Throughout his life he kept a meticulous record of his work and engineering observations. His journal, memoranda and correspondence are preserved at the Science Museum, South Kensington, London.

143 The rotary valve used by Oliver Evans on his later steam engines was the invention of Luther Stephens, a business associate of Evans in 1812. It was a disc of iron having on its underside certain channels to distribute the steam as it revolved in close contact with the cylinder ports.

Jacob Perkins' Steam Engine and Generator of 1822-1825.



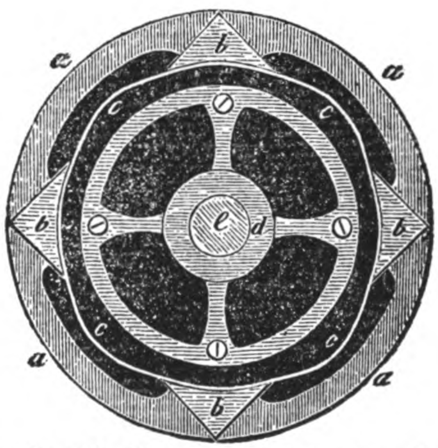
From *The History of the Steam Engine* by Elijah Galloway.

aa—The generator. bb—The furnace space. cc—The steam pipe to the engine. d—The loaded steam valve. e—The gear wheels which drive the rotary valve from the engine shaft. f—The slide bars for the piston rod cross head. g—The steam cylinder. h—The connecting rod driving the disc crank and flywheel i. j—Part of the foundation. kk—The exhaust pipe. ll—The condenser jacket. m—The hot well. nn—A pipe to convey the pump water up through the condenser jacket. op—The supply pump and lever worked from the engine connecting rod by the rod and chain q. rr—The hot-water pipe leading to the generator coil. sw—The loaded water valve between the heating coil and the generator. vvv—The water pipe leading into the generator. w—The spring balance pressure gauge. x—The thin copper safety tube in the pressure gauge pipe tt. y—An oil chamber to lubricate the piston rod. zz—Relief cocks for trapped air in the cylinder. The water circuit is represented by m, o, n, r, v, a, and the steam circuit is represented by c, g, k, l, k, m.

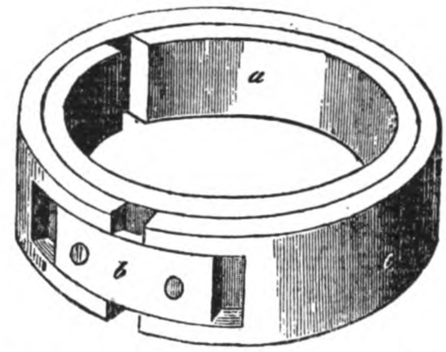
stated "it opened up a crack but did not burst." It was found that the gunmetal, while strong enough when cold, became exceedingly brittle when heated to 500 or 600 degrees.

During the summer of 1823, Perkins' steam engine was continually on display at Water Lane where he invited the greatest publicity. Field, also wrote Michael Longridge on May 6th and said: "The fame of Mr. Perkins has spread half over Europe, and I know of no invention or improvement that has excited so much attention as this . . . but certain it is that the public mind has never been more agitated by a scientific question than they have been by this."

The engineering firm of Robert Stephenson and Company at Newcastle-upon-Tyne had just been organized that year, to build steam engines and locomotives. The company included the celebrated George Stephenson, father of Robert Stephenson, Edward Pease and Michael Longridge. The partners were naturally much concerned at the sensational developments in London, for they believed that if Perkins' system of generating steam



The Metallic Piston invented by John Barton and successfully used on Perkins' Engine.
b—The wedges that press the segments a—against the cylinder walls. c—Flat spring.



The Metallic Packing Rings made for Perkins' Engine by Joshua Field in 1823.
a—The inner expanding ring. c—Ring in contact with the cylinder walls. b—The sliding tongue to seal the joint.

was successful, their own patents would be seriously jeopardized. A special journey to London was undertaken by Robert Stephenson and his father, to see for themselves what Perkins was about and how he generated steam in a red-hot boiler. They appear to have stayed several days in London and visited Perkins frequently. Robert Stephenson, writing to his partner Longridge on September 10, 1823, remarks that his father "one day stopped the engine by his hand, and when he called the next day, Perkins had previously got the steam to such a pitch (equal to 15 atmospheres) that it was impossible for one man to stop it, but by a little of my assistance, we succeeded in stopping it by laying hold of the flywheel." Robert Stephenson continues with native shrewdness: "This engine he formerly called a 8 or 10 horsepower but now only a 4. I am convinced, as well as my father, that Perkins knows nothing about the principle of steam engines." From which it is evident that Perkins' invention was not at that time in sufficient strength to satisfy his more matter-of-fact engineering contemporary.

Among other mechanical difficulties Perkins had endless trouble with his pistons and

the packing around the piston rods, due to the high temperatures. Perkins tried many types of pistons, one was specially made at the works of Maudslay, Son and Field at Lambeth to the design of Joshua Field, but the best results were obtained with a piston invented by John Barton[144] for which he had obtained a patent in 1816. Complimenting Barton on the satisfactory performance of his piston, Perkins wrote:[145]

Mr. John Barton,
Seward Street, Goswell Street, London.
Dear Sir:

I have used your Patent Piston and Stuffing-box above three months in my engine. The friction is much less than any I have tried. I have had the steam up to 1400 lbs. to the inch, without any leakage to signify. I generally work with steam from 400 to 500 lbs. to the inch, and find them quite tight enough for all practical purposes. The wear appears not to be the least objection to them.

I am, Sir, Your obedient servant,
Jacob Perkins.

41 Water Lane
July 24 1823.

Again Perkins wrote in his treatise: *The Concentrating Steam Engine* in 1824 that Barton's piston was the best as yet for his purpose but was far too costly and complicated.

As a steam-tight piston has always been considered a great desideratum, I was induced to try several: none but Barton's promised much under such high pressure, and Mr. Barton's piston, although very ingenious and effectual, was too complicated and expensive to answer my purpose if one more simple could be obtained. After some study I was so fortunate as to make an improvement on Field's piston, which fully answers the purpose, combining simplicity flexibility, durability, and economy. It is made of cast steel, of a spring temper, three inches and a half in diameter and has been found to retain its elasticity, although working at a blue heat for six months., and when ever examined, its rubbing parts were found highly polished, and the other parts a constant blue. The piston rod is stuffed on the same principle.

Quoting from the same source Perkins explained the difficulty of getting a boiler of sufficient strength for his purpose, the cast gunmetal generators having proved quite inadequate for the extreme pressures which Perkins visualized:

The difficulty of getting my generators made tight enough has occasioned great delay which very much alarmed my friends and gave an opportunity for my opponents to say, that the visionary scheme had, as they prognosticated, entirely failed: but as I never once doubted that I should succeed in getting my generators made to my mind, I felt quite at ease on that score. I, however, extremely regretted the delay which this practical difficulty occasioned, especially as the public mind was highly excited, in consequence of the great expectations raised by the novelty and promise of the theory. I have at last the pleasure of having my anticipations and wishes perfectly gratified. After consulting with

[144] Barton's invention was the first all-metallic packed piston to satisfactorily stand up to working conditions. It was made with four semi-circular segments which were pressed against the cylinder wall, by four wedges operated by springs inside the piston. Barton's piston, with some variations, held its own in England, France and America for many years until the advent of the spring ring now in common use in all reciprocating engines. Barton also devised on the same general construction a metallic packing for piston rods but this failed to come into use as soft packing was found adequate for the low pressures and temperatures that then prevailed. John Barton is listed in the directory at this period as a "Metallic Piston Manufacturer, 21 & 29 Providence row, Finsbury. Presumably the Seward Street address to which Perkins addressed his testimonial letter, was Barton's private residence.

[145] Reproduced from the *Register of the Arts and Sciences* of December 17, 1825.

Mr. Russell, of Wednesbury, in Staffordshire on the best method of executing this piece of work, he at considerable expense has succeeded in delivering me the best piece of workmanship in wrought iron, that was perhaps ever produced. This part of the generator (which is denominated the receiver) has sustained a pressure of 1400 atmospheres or 19,600 lbs. on the square inch; it is cylindrical eight inches external and five inches internal diameter, with each end drawn in hemispherically; it is made of scrap-iron, and without joint or rivet.

Perkins made frequent business trips to various parts of England in connection with his engraving work for the country banks. This enabled him while in the Midlands to contact the firm of James Russell and Company of Wednesbury, one of the principal manufacturers of wrought iron pipe; Wednesbury and district were famous for their iron works where gun barrels, gas pipe and other specialized forgings in iron were manufactured. The town is about five miles to the north of Birmingham and it is recorded that in 1777 James Watt sent to Wednesbury for his piston rod forgings. Previously all iron pipe was butt or lap welded by hand, requiring the greatest skill and rapidity of execution by the smith, but by 1824 James Russell had commenced making wrought iron pipe by machinery. The welding was done under a tilt hammer and the pipes afterwards were finished to size by passing them between two grooved rollers.

The first steam engine which Perkins constructed underwent considerable alteration during 1823, principally to the generator, furnace and the distributing valve of the engine. Of this latter part, Perkins said: "It was made first of cast-iron but wore so fast that I was compelled to use chilled cast-iron." The difficulty of turning such hard metal was overcome, Perkins claimed, by a slow motion which did not exceed 6 linear feet per minute at the point of the cutting tool. The first engine was rebuilt with a cast iron cylinder 3½ inch bore and 14 inch stroke. The crosshead was altered also and was remade with two cast iron rollers working to and fro in a strong box of steel to reduce the friction due to the oblique thrust of the connecting rod. The method of heating the water was also changed and the complete system is shown on Plate XXIII. The generator was then termed by Perkins a "receiver" and was 13 inches long. The principal heating element was now a coil of pipe that formed the inside wall of the furnace. It is stated that this coil was 80 feet long, ⅝ of an inch inside and 1¼ inches diameter outside. Perkins said the coil could be made from copper or wrought iron scrap. This length of pipe was probably also made for Perkins by Russell and Company at Wednesbury. This pipe when coiled was 2 feet in diameter and 2 feet high. On the outside was a sheet iron case 2 inches larger than the coil and this space was filled in with iron cement to concentrate the heat. One end of this heating coil went to the force pump driven by the engine and the other end entered and passed down to the bottom of the receiver which was entirely filled with water. The water was preheated before entering the coil by passing up inside a copper jacket that surrounded the exhaust pipe. Here the waste steam from the engine was condensed and flowed back by gravity to the hot well from which it was pumped back through the heating coil into the receiver; thus, bar leakage, making it a closed system.

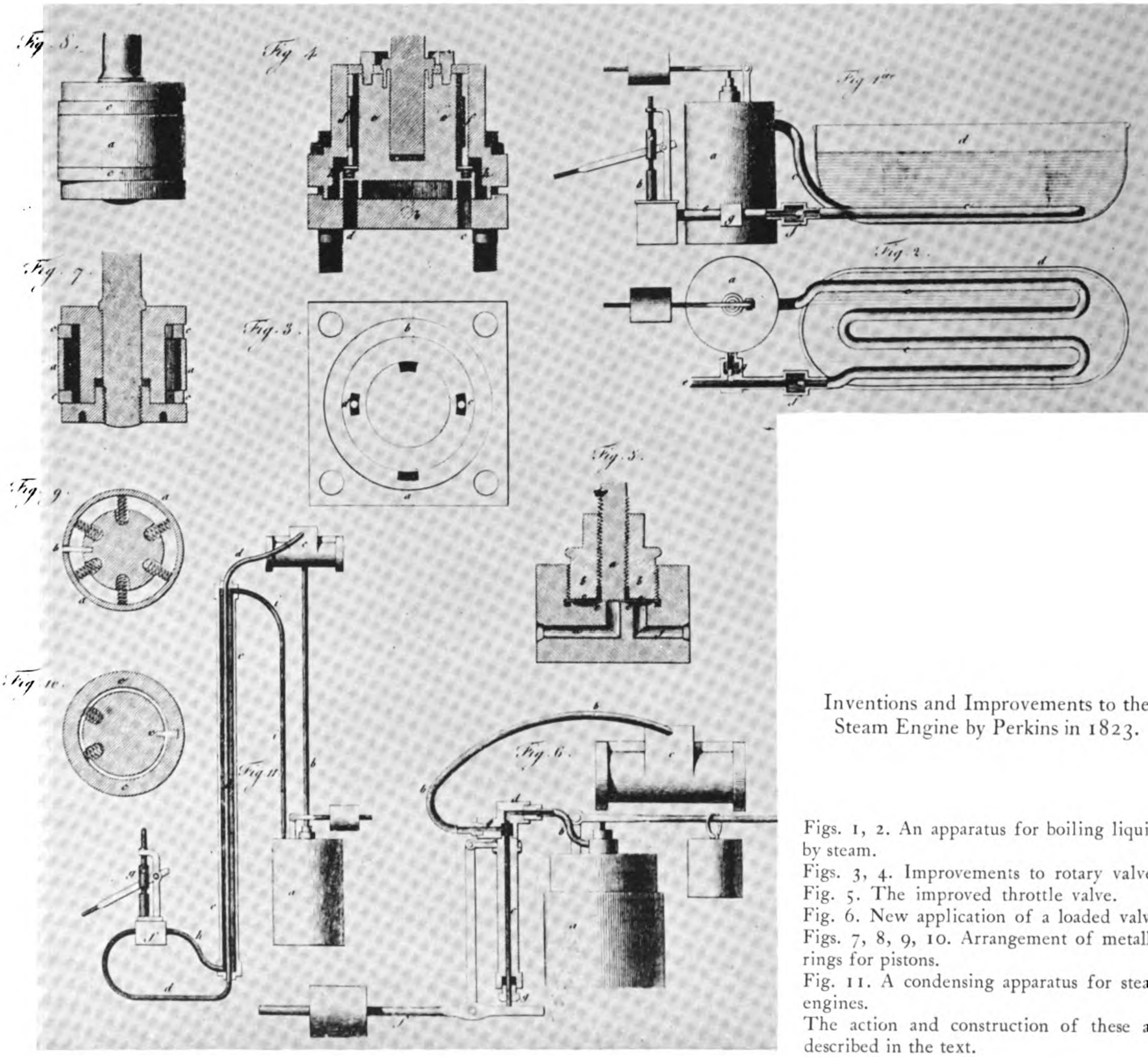
As no safety valve was possible under this arrangement, Perkins devised a safety tube of thin copper inserted in the steam pipe at X. This was calculated to burst at 1,000 pounds per square inch, 200 pounds more than the maximum working pressure. The pressure gauge shown at W consisted of a well-fitted piston having an area of 1/14 of a square inch sliding in a cylinder connected at the bottom to the water supply pipe. The amount shown

by the indicator hand on the dial of a spring balance equaled for every pound on the gauge piston, 14 pounds in the receiver.

A fan blower was provided which forced the air first over the condenser to cool it and then into the furnace at the top through the slanting pipe as shown on the drawing, driving the smoke downwards through the ignited coals where the smoke was completely consumed. The heated gases then circulated upwards between the wrought iron case surrounding the coils and the brick retaining walls. This feature for down draught and consuming the smoke was adapted for use on low pressure boilers and a joint patent was taken out, dated November 20, 1823, by Perkins and John Martineau, Jr., an engineer of City Road, London.

It is not very clear just why Perkins and Martineau co-partnered in this particular patent, for Martineau's name never crops up again in any business dealings involving Perkins. John Martineau, Jr., was a son of John Martineau, who was one of the first vice presidents of the London Mechanics' Institute, founded December 2, 1823. The Martineaus, father and son, traded under the firm name of Taylor and Martineau, Engineers and Patentees, who manufactured small horizontal factory engines. They were also promoters of Oil-gas and manufacturers of hydropneumatic pumps used by The London Portable Gas Company.[146] The connection between Perkins and young Martineau may well have been through the manufacturing of these pumps, as Perkins in 1822 was conducting experiments on the compressibility of water and gases and would have required this sort of apparatus. Later the Martineau manufactory would have supplied castings and machined parts for the first experimental steam engine as the Water Lane premises do not appear to have been well equipped for this type of work, and the joint patent was probably Perkins' way of paying for the Martineaus' assistance. For as far as can be ascertained, the invention was never forwarded in any practical way at the time. The necessity for smoke consuming devices at this period is more obvious. The great increase in manufactories in London using steam engines had finally brought the smoke nuisance to a head in 1819 and an Act of Parliament was passed in 1821 to facilitate the prosecution of offending factory owners. This act did not apply to the smelting of metal nor to mines, it was aimed more particularly to cities, but the almost universal use of soft coal in England prevented any real relief from this problem. Perkins, as previously mentioned, employed a down draft through the furnace of his steam engine and this method of admitting the air and igniting the fuel at the bottom does not seem to warrant it being an original invention. This principle, known as the magazine or base burner stove, had already been the subject of many patents. Allan Pollock's heating stove of 1807, already referred to, was constructed on this order. James

[146] At this period the relative advantages of coal gas and gas made from palm oil for illuminating purposes were undecided. In 1824 Newgate Prison was first lighted by means of David Gordon's patent oil burning lamps. Compact gas making units were used for buildings and houses, consisting of a small heating stove and a retort which contained broken brick. Onto this the oil dripped and instantly vaporized, the gas so formed could be used directly without the necessity of a gasometer. The gas was also compressed by means of a special pump, into small iron containers for portable lighting by the gas company already mentioned. Oil gas cost to manufacture on an average of twenty-seven shillings per 1,000 cubic feet and it could not compete with coal gas of that day which sold for about twelve shillings per thousand feet. The advantage of oil gas was in its illumination properties which were as three to one over coal. The possibilities of using oil or oil gas in the furnace of his steam engine in place of coal seems to have intrigued Perkins about this time for he declared to a friend in 1824 that "he felt certain of being able in a few months to go from London to Liverpool [203 miles] with the steam produced by a gallon of oil."



Inventions and Improvements to the Steam Engine by Perkins in 1823.

Figs. 1, 2. An apparatus for boiling liquids by steam.
Figs. 3, 4. Improvements to rotary valves.
Fig. 5. The improved throttle valve.
Fig. 6. New application of a loaded valve.
Figs. 7, 8, 9, 10. Arrangement of metallic rings for pistons.
Fig. 11. A condensing apparatus for steam engines.
The action and construction of these are described in the text.

Plate reproduced from the *Bulletin de la Société D'Encouragement pour L' Industrie Nationale*, Paris, 1824.

Watt was the first to patent the hopper feed for steam boilers in 1785 but with no other intention than that of consuming the smoke.

Several months of trial of the concentrating engine with steam pressures hitherto unknown had shown definitely that the accepted mechanical practice of the times was inadequate to stand up to the temperatures of 500 degrees and over, for it was the friction caused by the excessive heat that scored and destroyed the moving parts which came into direct contact with the super-heated steam. Perkins used for his cylinder lubrication a mixture of about equal parts of Russian tallow and olive oil which was solid at normal temperature but fused at 85 degrees, but this oil quickly found its way back into the hot well and gummed up the pump valves. There was at this time absolutely no lubrication known that could cope with cylinders, pistons and rods that turned blue under normal running conditions. This fact compelled Perkins to specially design almost every working part of his engine before he began to achieve a fair measure of reliability of operation. On June 5, 1823, Perkins applied for a patent for "certain improvements in steam engines." This, by the way, was supplementary to his first steam engine patent and covered the construction of its parts as follows: first, an improved rotary valve, Plate XXIV fig. 3 and 4, which was balanced to the extent of carrying on its surface only a small proportion of the steam pressure. This was a beneficial alteration from the earlier valve used (this was a flat disc 3 inches in diameter), which revolved under a load of approximately two tons at 500 pounds pressure. The key letters to this valve are, e.e. the rotary valve with its driving spindle in the center, a. is the steam supply port, b.g. is the exhaust port, d. and c. are ports leading to each end of the cylinder.

Perkins quickly found that any form of stuffing box employing a soft gasket burned out rapidly and serious leakage ensued. To overcome this defect in his steam valves he devised a dished steel disc which covered the two steam ports entering the valve chamber at d. and f. Then by means of a threaded spindle a., which required no packing, the disc could be screwed down hard over the center opening.

A threaded valve spindle could not always be used and Perkins, in his third specified improvement to his steam engine, describes a rod valve shown at fig. 6, in which the stuffing box is placed at the bottom so that some condensed water would always be descending and so keep the gasket cool.

The fourth improvement was for a metallic packed piston, shown at fig. 8. The piston was made in two parts to allow the three rings to be fitted on as indicated at fig. 7. The center ring, fig. 9, was split and held centrally by six coil springs. The two rings c.c. on each side of the center ring were solid but free to move laterally. See fig. 10. These rings required no lubrication as they were made from a special bronze alloy, the composition of which will be referred to later.

The fifth improvement was a condensing apparatus, fig. 11, and this shows how the exhaust steam from the cylinder c. passed through a pipe d.d. on its way to the pump f.g. This steam jacket heated the water that was being forced by the pump into the receiver. In actual practice the exhaust steam passed after condensing into a sealed hot well before reaching the pump.

At figs. 1 and 2 is shown Perkins' apparatus for heating, boiling and evaporating by steam in pans, boilers and other vessels. Another patent was taken out May 17, 1823, for this application of steam and this method would no doubt have been of benefit to brewers,

dyers, rectifiers, and chemical manufacturers. The drawing explains itself. The heating coil c.c. immersed in the pan d. is supplied by live steam as required by working the pump.

This method of boiling by the application of live steam from a remote source has been extensively used, perhaps never more so than in the present day. In Perkins' first steam engine Patent No. 4732, he illustrates and describes a means of injecting steam at high temperature into the existing steam boilers of that day. His intention was of course to induce owners of low pressure steam engines to use his patent as a means of saving fuel. As will be noted on Plate XXII in the lower drawing, a pump is used to force water through a pipe G into the heating elements AA of which there could be any number. These were heated by the furnace as shown. At each stroke of the pump the loaded valve LW lifted and steam passed into the pipe C which entered the water contained in the existing low pressure boiler. The superheated steam by giving up its heat, produced a great quantity of low pressure steam in the larger boiler. Perkins believed that by this application of heat a considerable saving of fuel would be obtained, but it seems obvious that only so many cubic feet of steam can be raised in a boiler by so many pounds of coal burned in the furnace and any roundabout way must be but an expedient and not a fuel economy. There is no record that this method of Perkins was ever put into practical use. There is evidence, however, that he applied about July, 1823, to the Borough Water Works, Lambeth in South London, for permission to demonstrate his plan for injecting live steam. Permission was readily granted to do this by the proprietors of the Water Works, but according to a correspondent, in the *Mechanic's Magazine* of November, 1823, it was said of this project "that nothing had been done, nor likely to be."

Another correspondent of the *Mechanic's Magazine* at this time was J. W. Armstrong, Perkins' erstwhile partner in the first nail machine. Written from Bristol and dated October 16th, Armstrong asked the editor for information about Perkins' engine. He wrote: "As a countryman and acquaintance of the inventor, I feel a little interested in his mechanic celebrity." He then goes on to remark: "As I have not seen the engine, I am rather at a loss for data. I should like to be informed, through the medium of your useful Magazine, the means used to fasten the different pipes into the generator, whether by screwing them in or otherwise; it does not appear from the design how this is effected." Armstrong could have been better informed by writing directly to his one-time business associate, but apparently his curiosity was not equal to a renewal of their old acquaintanceship.

There is no doubt that Perkins at this period was spending all his time and a great deal of money on furthering his experiments with the flash steam generator and engine. He conducted this end of his work under the title of Perkins and Company, while the engraving business continued as Perkins and Heath. These latter apparently were made financially responsible for carrying on the engine experiments. It is on record [147] that the Fleet Street firm finally put in a claim for £679 against Perkins and Company for proportion of rental of 41 Water Lane, part cost of workmen's wages who were taken from their regular employment, losses on the steam engine, etc. etc. as of between November, 1822, and September, 1824, and an arbitrator, a Mr. Bates, was called in to settle the matter. On February 4, 1825, this controversy was decided in the favor of Perkins and Heath. From this it may be surmised that while Perkins' experiments created the greatest excite-

[147] From records in the possession of Messrs. Perkins, Bacon and Company, Limited, formerly of Southwark Bridge Road, London.

ment and interest in both engineering and scientific circles throughout the world, his work was not looked upon with favor by the members of his Fleet Street firm who objected to this diverting of their funds. Like all projectors of new things Perkins had his stanch partisans as well as those who were openly skeptical of this new steam power. These latter critics, whose views were biased no doubt by the rather inconclusive evidence which Perkins had so far been able to produce, treated the experiments with scant respect. Elijah Galloway, the civil engineer, said in his *History of the Steam Engine* regarding Perkins' engine of this period: "There have been so many exaggerations and misrepresentations respecting this engine from first to last, that we cannot venture to give credence to anything on the subject, without seeing this alleged improvement in actual practice."

One of Perkins' earliest champions was the estimable Prof. Robert Jameson,[148] who was the editor of the *Edinburgh Philosophical Journal*. From the first, even as early as 1820, Prof. Jameson had published almost everything current pertaining to Perkins' work, giving a fine publicity as well as a friendly interest to the newcomer. In 1823 Prof. Jameson published the account of Perkins' experiments on the compressibility of liquids, the crystallization of acetic acid and the liquefaction of air experiments. When the steam engine demonstrations became public, Prof. Jameson expressed through his journal a sympathetic interest in all that Perkins did. Then somewhat abruptly this benevolent attitude on the part of Prof. Jameson changed, as did that of many others whose good opinions could have profitably been retained, for Perkins began too heavily to mix his practical experiments with extravagant promises of glory and gain which promises far exceeded anything he could demonstrate at the time. Among other notables who visited the steam trials at Water Lane was Dr. Edward Church,[149] then American consul at L'Orient in France, who had made a special trip over to London to witness the triumphs of his fellow countryman. At the suggestion of Dr. Church, Perkins wrote an elaborate paper upon his experiments past and present. In this he was ably assisted by his friend, Gibbons Spilsbury of London, who was related to the Spilsbury family of artistic and engraving fame. Dr. Church, on his return to the continent, conveyed this treatise to Geneva where he immediately had it published in the *Bibliotheque Universelle* of March, 1824. It seems that this rather premature and ill-considered effusion of Perkins reached the eye all too soon of the hardheaded Prof. Jameson who, wasting but little time, tore

[148] Prof. Robert Jameson, 1773-1853, was born in Leith, Scotland. In 1804 he was appointed professor of natural history at Edinburgh University. For many years he had been joint editor with Dr. David Brewster of the *Edinburgh Philosophical Journal* but by 1820 Dr. Brewster had withdrawn from the paper to start another publication called the *Edinburgh Journal of Science* and Prof. Jameson continued as sole editor of the original journal. The deep interest taken by Prof. Jameson in Perkins' experiments with steam dates from an address delivered before the Royal Society of Edinburgh in 1823 by Capt. Basil Hall of the Royal Navy, a friend of Perkins from London, and no doubt at that time the scientific angle of Perkins' invention held more interest for those learned Scottish philosophers than its commercial possibilities. In 1822 Prof. Jameson had his residence at No. 21 Royal Circle, Edinburgh.

[149] Dr. Edward Church, 1779-1845, born in Boston, Massachusetts. He was educated in England and France and served with Napoleon's forces in Spain. In 1817 he was appointed by President Madison consul general at L'Orient and adjacent ports of Brittany. His great interest was steam navigation and a great part of his career in Europe was employed in promoting steamship service on rivers and lakes. He superintended the construction of the first successful steamboats on the rivers Garonne and Rhone and the lakes of Italy and Switzerland. One of these steamboats was the *Léman* of 269 tons with engines by Boulton and Watt. This was in service on Lake Geneva in 1826. Dr. Church's keen interest in Perkins' engine was because of its economic possibilities for steam navigation.

into the article with gusty fervor. In the next issue of the *Philosophical Journal* dated July, 1824, there is to be found the Professor's extremely candid opinions:

> Having read the paper, we really see nothing advanced in it which tends in the least to alter the opinions we had previously formed. . . . We are here presented with such a mass of mere theories and assumptions, together with such fanciful paradoxes, and downright absurdities, as we believe have seldom been brought forward in the shape of philosophy. . . . The editor does conceive that; he [Perkins] appears to entertain, in some respects, very correct views on the nature of heat and its expansive force. . . . His proposal to *pump back the heat* into the boiler, after it has done its office of impelling the piston in the cylinder; consists merely in heating the water of the generator by the waste steam from the cylinder, a plan which has been already frequently proposed and practiced to a certain extent in every steam engine in the kingdom.

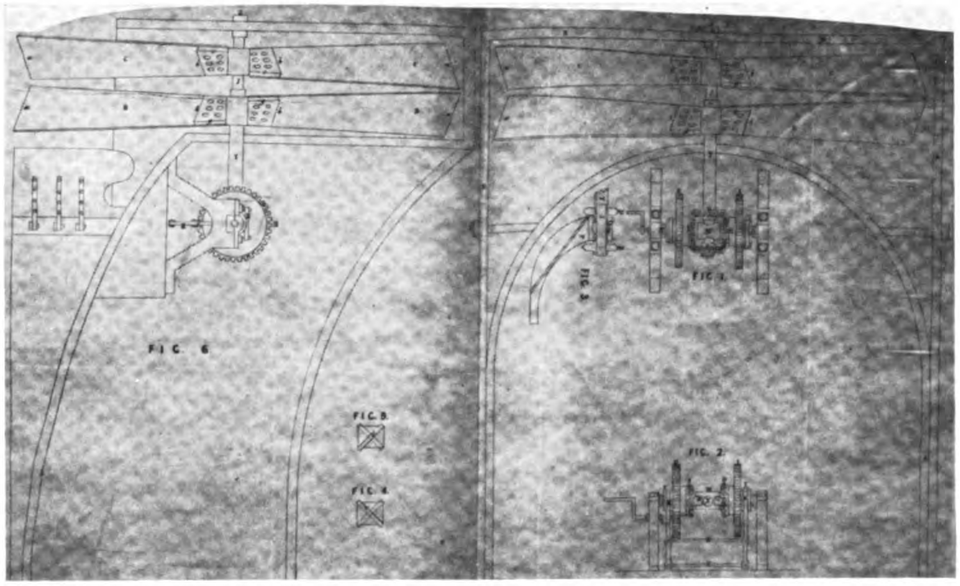
After this frank expression on the part of Prof. Jameson, Perkins' name as well as his theories and further experiments with steam, were banned from the pages of the *Philosophical Journal,* nor was there ever again any mention of his work.

As the publicity spread far and wide concerning the trials of Perkins' steam engine, he became the center of the wildest rumors, one of which we quote from a London correspondent, which was sent to America and appeared in the *Columbian Centinel* of Boston, dated September 13, 1824:

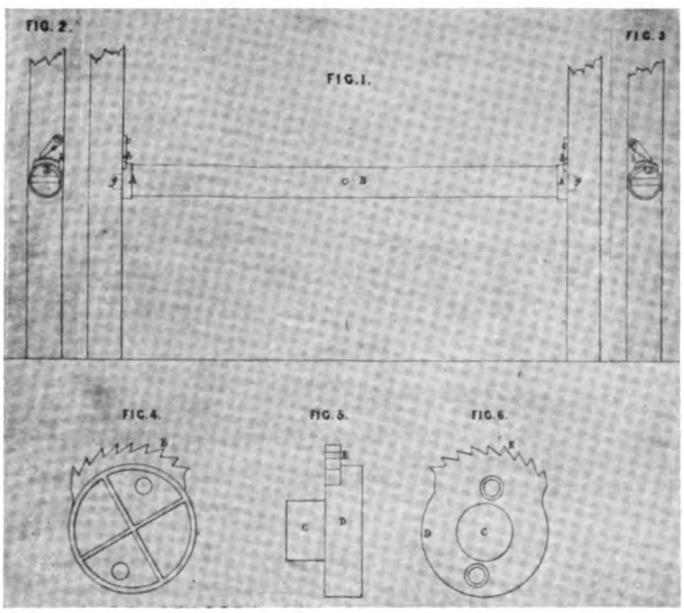
> You will be gratified to learn that our countryman, Jacob Perkins, is about to profit from his new invention of which he requests me to say, he feels the utmost confidence, both in its security and economy. Several of the engines are on the point of completion, and their erection on board of steam vessels only wait for the sealing of a new patent, which Mr. Perkins is soliciting, for a peculiar kind of paddles to be made the propelling agent. The paddles are a material improvement, which lately suggested itself to our ingenious friend, while experimenting on the engine. They are designed to be placed under the stern of the vessel, to be made of iron, and have an alternate movement in the water; forming, I think, a capital substitute for the heavy wheels at the sides. In the course of a fortnight it is supposed, one of the new engines will be in readiness to be placed on board a small vessel on the Thames, for the purpose of satisfying public curiosity.

The improved paddle wheels which are referred to were patented by Perkins on August 9, 1824, and are shown on Plate XXV. The two large fanlike wheels revolve in opposite directions, one shaft running inside of the other. Only about one-third of the wheels were immersed in the water. The patent specifications are very involved and the subject scarcely justifies giving it in full. A brief reference to the parts shown on the drawing will suffice. The four beveled gears shown at fig. 1 DEFG revolve the propellers in opposite directions when one or the other of the spur gears HI are driven from the engine. RRRR is a frame pivoted outside the vessel at SS and supported the propeller shaft at Z. The object of this arrangement was to raise or lower the propeller blades according to how deep the vessel was laden. The pitch of the blades was 45 degrees at the boss, lessening to 22½ degrees at the tips. Fig. 3 shows the bracket which supported the inner shaft bearing at M. Provision was made for going ahead or astern by shifting the frame KKK by means of the screw and crank handle shown at L. This motion engaged a catch connected with the spur wheel H with the bevel wheel F, at the same time releasing a catch with the spur wheel I and bevel wheel G and vice versa. No information has come

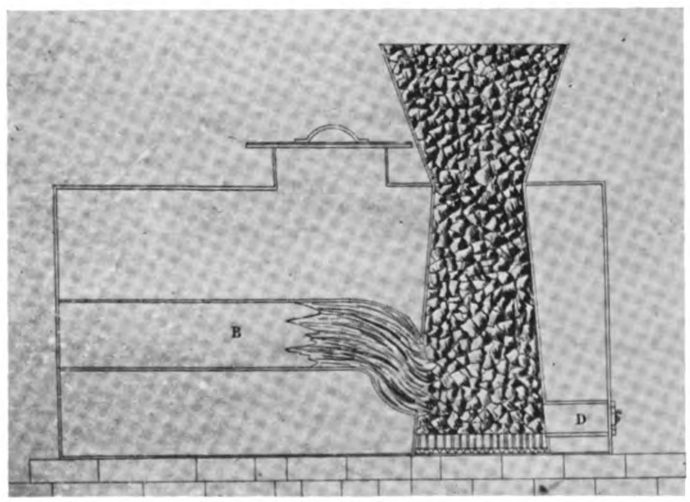
Miscellaneous Patents.



Perkins' Double Paddle Wheels of 1824. From the patent drawing. Described in the text.



Perkins' improvements in the construction of bedsteads and sofas, 1825. From the patent drawing.



Perkins' and Martineau's Smoke Consuming Furnace of 1823. From the patent drawing.

From copies of the specifications in the United States Patent Office.

to hand as to whether this improved propeller was actually ever put into practice. It is recorded, however, that some trials were made on the Thames by Perkins as an experiment. David Napier, the celebrated engineer of Mill Wall, London, the inventor of the Steeple type marine engine, patented in 1841 an almost identical double paddle wheel on Perkins' plan. For what reason it is hard to understand.

Though small steam vessels had been plying the coastal and inland waters of the British Isles for more than a decade, it had been considered feasible only within the previous year or two to use the steam engine for prolonged deep sea voyages. The most coveted market at that time was the trade with Bengal, for long a monopoly of the Hon. East India Company and it was hoped that this slow and tedious route, averaging some ninety days by sail around the Cape, could be accomplished more quickly by steam power. This idea was of course fanned into a blaze quite as much by steamboat builders as by the merchants and shippers themselves. In 1823 The General Steam Vessel Company got under way with a proposed capital of £44,000, to be subscribed by members either in cash or in lieu by donating their steamboats for the company's use. The principal object of this company was a steamship service between London and Calcutta and meetings were regularly held at the London Tavern in Bishopsgate Street by all those who were interested in the project. Perkins' high pressure generator and engine, so new and so promising, seemed to provide a likely solution to the problem of steam versus sail and he, no doubt, pressed his claims hard toward its adoption for the Indian service. The following extract from the *Edinburgh Journal of Science* of July, 1824, gives a most enlightening view on the subject:

> Mr. Perkins is we learn, busily employed in fitting out a steam boat with one of his engines to go to Calcutta by the Cape of Good Hope. A steam boat from the Thames entering the Ganges will complete the triumphs of this distinguished mechanician. It has been stated to us that Mr. Perkins has received the sum of £36,000 from an enterprizing individual for a share in his patent.

And again we quote from the same journal of that year:

> An engine is now constructing, to be taken to the United States by Mr. Goodrich, of Connecticut, in July or August—he being appointed the agent of Perkins and Company to manage their affairs there. Thus, you see, the people of the United States are likely soon to have an opportunity of judging for themselves of the success of their ingenious countryman, without being left to doubt amid the contradictions of interested publications.

The agent mentioned in the foregoing communication was Samuel Griswold Goodrich[150] the celebrated traveler and author. He toured Europe, including England and Scotland, extensively between the years 1823 and 1825 and it is to his impressions which he prolifically recorded in his book *Recollections of a Lifetime* that we owe the following account of his meetings with Perkins in London: [151]

---

[150] Samuel Griswold Goodrich, born in Ridgefield, Connecticut, August 19, 1793. He traveled extensively in his early life, accumulating a great fund of personal anecdotes of personalities of his day. He wrote poems, tales, essays and history prolifically. His writings, so popular under the pen name of "Peter Parley," were translated and republished in many European countries. In 1859 Goodrich retired from active authorship and a year later he died in New York on the 9th of May.

[151] *Recollections of a Lifetime or Men and Things I have Seen* by *Peter Parley* (S. G. Goodrich) 1857, Vol. II, pp. 225-227.

Mr. Perkins' establishment was in Fleet Street, no. 69 when I was in London. One of the superintendents of this was Mr. Charles Toppan, now so well known in connection with the eminent firm of Toppan, Carpenter and Co. To his intelligence and kindness I was indebted for much of the pleasure and profit of my first visit to London. Here also was Asa Spencer, originally a watch maker of New London, and the inventor of the geometric lathe, for copying medals, as well as other ingenious and useful devices. He was a man of true genius, full of goodness, modesty and eccentricity. The house of Mr. Perkins, at this period, was a familiar gathering place for Americans in London, his charming daughters giving a sense of American life and grace to all around them. His son, Angier M. Perkins, a gentleman of great talent, worth and kindliness, continues his father's establishment in London.

Though Goodrich does not say just when he visited the Fleet Street establishment, it may be assumed that this was in the summer of 1823. The reason for this deduction is that Asa Spencer was still there. His contract with the firm, as will be remembered, was for three years and it is known that Spencer was back in Philadelphia by 1824. Goodrich, speaking of Perkins' charming daughters whom he had met at the Perkins home (this presumably meant No. 69 Fleet Street) referred to Sarah Ann who had several years before married Joshua Butters Bacon, Louisa Jane who died young in 1833, Elizabeth who later married Dr. Henry Roy of Virginia and Henrietta who became the wife of Harry Chubb.

That Goodrich became sufficiently interested to actually become an agent for the Concentrating Engine in America is not borne out by any evidence. He was essentially a scholar and would not have been likely to engage in this sort of mechanical enterprise. The whole proceedings at this time are shrouded in mystery and the fact does not emerge that Perkins' engine was ever tried in a vessel and it cannot be ascertained at this late date whether the wild statements that appeared in print emanated from Perkins himself or were the garbled accounts which correspondents transmitted to their papers.

Apparently Perkins did not attempt to apply his engine to a steam carriage, though in many respects this seemed a logical step, for his engine and boiler could in the light of such high pressures have been made very compact. These were the most intensive years of steam carriage experiments on common roads and between 1824 and 1836 many very successful steam coaches were constructed and operated with reliability and safety.

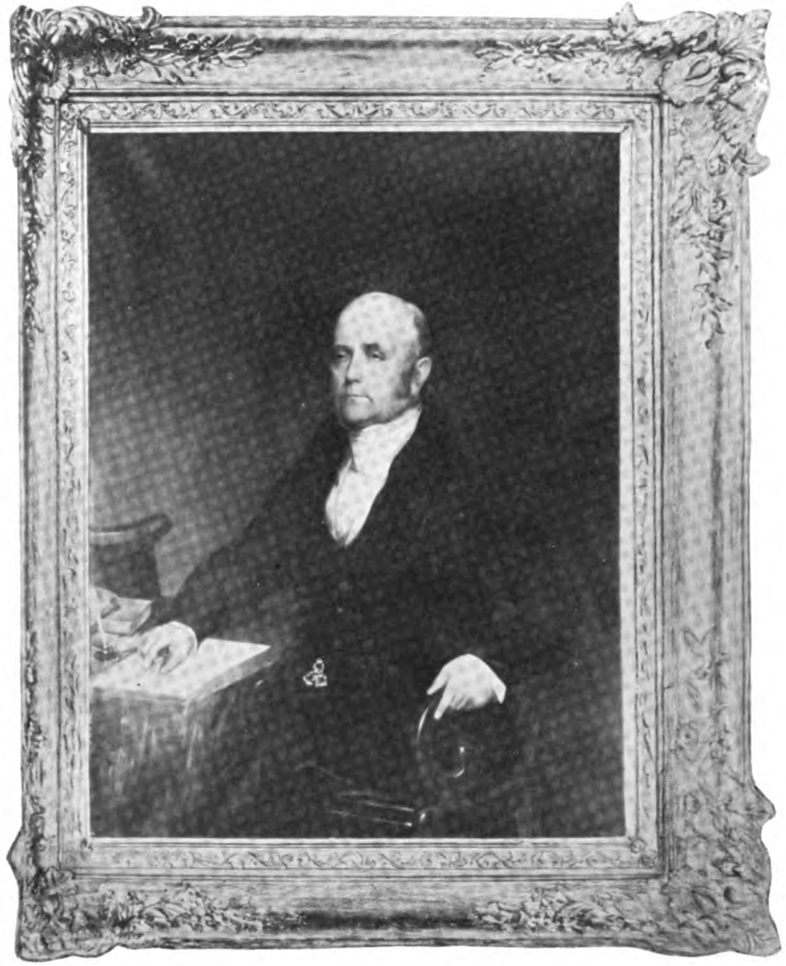
Matthew Murray,[152] the engineer and manufacturer of Leeds, writing to Simon Goodrich in a letter dated November 21, 1824, and commenting on the practical problems of locomotive engines, says: [153]

I am afraid nothing can be done by Mr. Perkins' scheme without increasing the danger, however a steam carriage would have been the best to have made his experiment upon, as he pretends to get great power, with little room & no danger. This I cannot understand & in the absence of direct experiment he cannot satisfactorily explain.

In spite of what Perkins promised regarding his engine, the answer to this could well have been that he was himself very far from being satisfied with its power and performance. This is borne out by the fact that several years later he designed and patented an entirely different type of engine and boiler, though he still retained his extreme pressures.

[152] Matthew Murray, 1765-1826. Engineer, inventor and pioneer in early locomotive construction. His manufactory, under the firm name of Fenton, Murray and Wood, was at Holbeck, Leeds in Yorkshire.
[153] From the Goodrich Papers. (Simon Goodrich.)

Mrs. Hannah Greenleaf Perkins and her granddaughter,
Maria Louisa Bacon.



Jacob Perkins.
Aged about 58 years.

These two oil paintings are in the possession of Messrs. Baker, Perkins, Limited, of Peterborough, England. They now hang in the company's board room, and were the gift of Mr. Loftus Patton Perkins, the great-grandson of Jacob Perkins. The artist was Chester Harding (1792-1866) of Massachusetts, an American artist who went to London in 1823 to continue his art studies and to paint portraits. He remained for three years before returning to America.

About this time the firm of Perkins and Heath were involved in an action at law by John Leigh Bradbury, a Manchester calico printer, who applied for an injunction in the Court of Chancery for an alleged infringement of his patent. Bradbury's patent is dated July 15, 1823, and the specification claimed "improvements in the art of printing, painting or staining silk, cottons, woolens and other cloths and paper, parchment, vellum, leather and other substances by means of blocks or surface printing." Bradbury also claimed that his improvements might be adapted to any description of printing press whether constructed with rollers or not and whether worked by hand or by machinery. The case was called in September, 1824, and in the course of the investigation Perkins showed that he had adopted the principle claimed by the patentee several years prior to the date of Bradbury's patent. After a full hearing of the evidence, by Lord Eldon the Lord Chancellor, the injunction was dissolved. While the plaintiff's suit in itself seemed puerile, it might well indicate that Perkins' engraved plates were already in use at some of the Manchester cotton mills and had proved detrimental to Bradbury's interests.

In the course of his experiments during 1823 and 1824 the tremendous power which could be obtained from steam had led Perkins to consider other uses for his patent generator. Perkins had observed that many small particles of metal, etc., were ejected with considerable force whenever the stopcock was opened. This occurred repeatedly until the solid sediment in the generator was entirely cleared out. This phenomenon suggested that with a properly constructed gun, bullets could be propelled with great velocity. Perkins estimated that while it took 500 to 1,000 atmospheres of pressure when gunpowder was used, only 40 to 50 atmospheres of steam pressure were required for the same effect, the difference due to the almost instantaneous pressure of gunpowder while steam expanded more uniformly and gave a constant force until the bullet left the barrel of the gun.

The *London Literary Gazette* early in 1824 gives a brief mention of this steam operated gun. It said the generator of Perkins' steam engine was connected to a short iron pipe which projected through a hole in the smithy wall at Water Lane, and the bullets were fired across the courtyard against an iron target. Of these preliminary trials between March 20th and March 27th, a news writer to an American paper gives the following item:

> Mr. Perkins.—A correspondent of the Commercial Advertiser, at present in London, writes on the subject of Perkins' steam gun to this effect. It discharges from a musket barrel (connected by a pipe, and some very simple machinery with the steam engine,) ounce balls against an iron target, at a distance of fifty feet; the balls are flattened to the thinness of ½ of an inch evincing an energy quite equal to that of gunpowder. Two hundred and fifty balls may be discharged per minute. You must not doubt this for I have seen it. To what extent this discovery may be applied in naval and military affairs, I cannot say. Mr. Perkins sees no practical difficulties in constructing engines to discharge from one tube 60 cannon shot per minute, with an efficacy equal to that of gunpowder.

From *The Annual Register* of 1824, under section headed Arts and Manufactures, is taken the following account of Jacob Perkins' first steam gun:

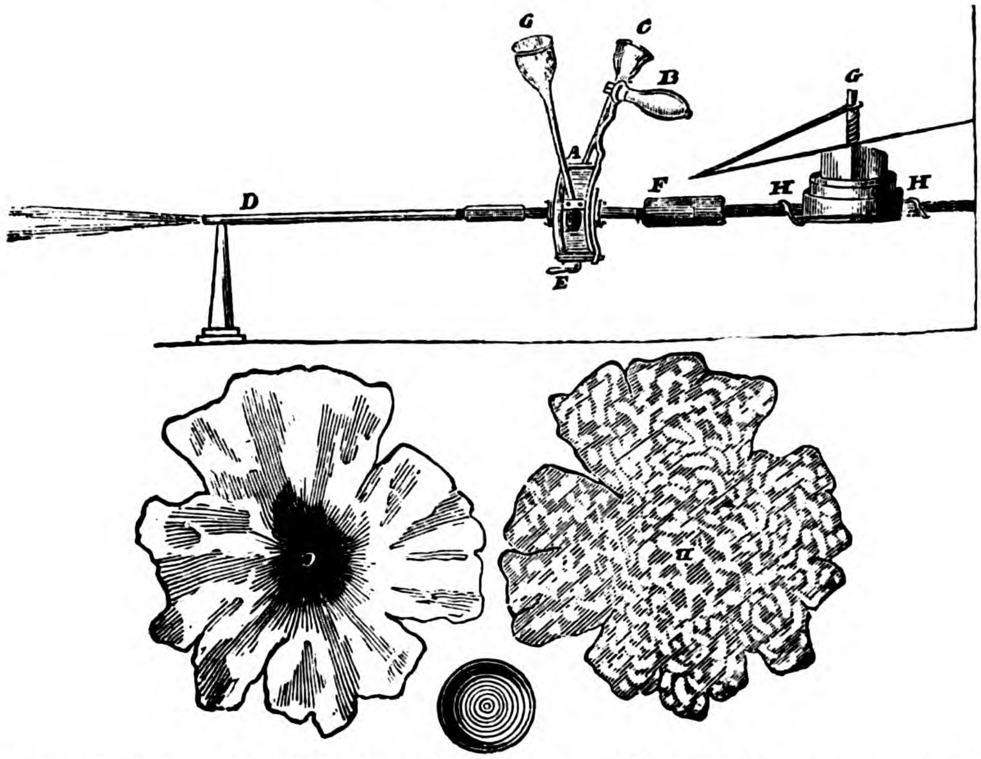
> As the gun is now fixed having direct communication through a wall with one of Mr. Perkins' engines, it cannot of course be moved from the spot, in the event of the invention being applied to purposes of warfare, it would be easy to attach a portable steam engine of small dimensions. Perkins is about to construct a four-pounder which can be moved about with great facility by two horses.

From these early experiments of shooting bullets by steam, Perkins' enthusiastic imagination soared to the possibility of using large cannon and gigantic mortars and he is credited with having said that a steam engine might be made which would throw a ball, a ton in weight, from Dover to Calais. Though modern gunnery has indeed fulfilled all that Perkins visioned, it has not been accomplished by the power of steam, nevertheless his prophecies in general have amply come to pass. Out of these experiments of Perkins with the steam gun came the idea of throwing shells and rockets by making these projectiles provide their own source of power. By referring to Plate XXVII, it will be seen that the rocket a. rests in an iron tube in the flame of a furnace d. in an inclined position subject to the trajectory desired. The walls of the rocket were of great strength and the rear end was closed by a small fusible plug c. made of brass and calculated to melt at high temperature and release the superheated water in a jet of steam which forced the rocket or shell into space. At b. b. are two iron rods which form a tail to accurately direct the flight. This invention was subject of a patent dated May 15, 1824, but strangely the specification does not mention the discharging of bullets by steam nor does it appear that Perkins ever patented this feature nor the steam gun itself. According to the specification, the rocket exclusive of the tail rods was 3 feet 6 inches long by 6 inches diameter and no provision was made for aiming it except by bodily shifting the whole furnace. Although this idea employed the rocket principle of flight, its usefulness or destructiveness would have been no more than that of a solid shot. Sir William Congreve seems to have been the first to use the rocket in warfare at the siege of Boulogne in 1806. It was no doubt Sir William's patent for a war rocket, the previous year of 1823, which directed Perkins' attention to this use for his high pressure steam.

From the *Literary Gazette* of June, 1824, can be quoted the following, under the heading of "Steam Rocket":

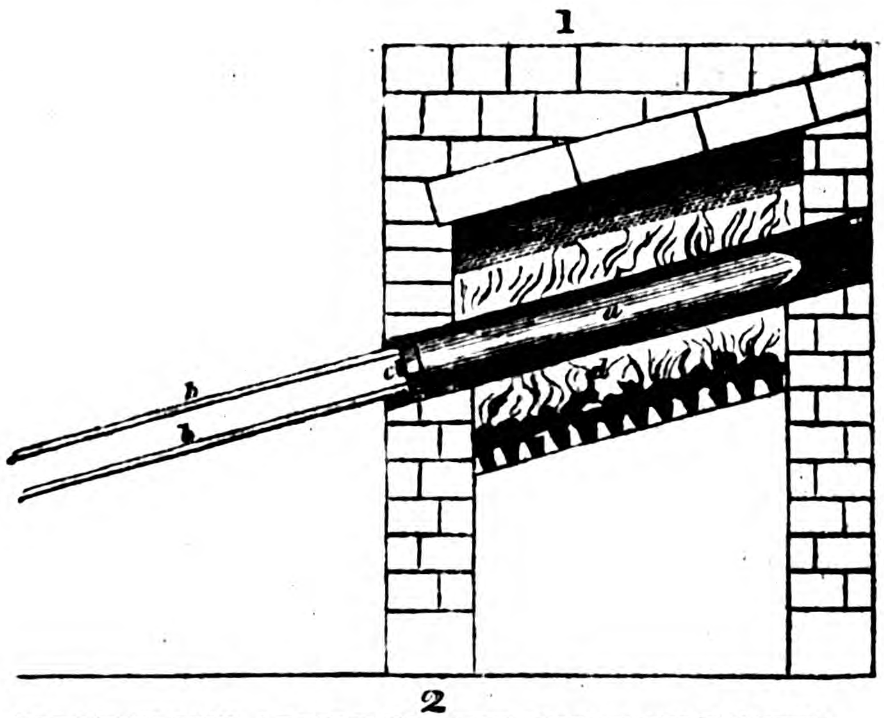
> In a recent number, we gave some account of the application of steam for the discharge of musket balls, by the ingenious Mr. Perkins of Fleet street, since which time he has been pursuing his enquiries respecting the stupendous powers of this mechanical agent, when subject to very elevated temperature. Mr. Perkins proposed to apply steam to the discharge of rockets of any size, of many hundred weight if necessary. When we consider the vast advantage which steam at a very elevated temperature possesses over gunpowder, in dispersive power, we see no reason whatever why it may not be made available to a considerable extent in projectiles; more especially in situations where ordnance may be kept stationary or nearly so. The expense of employing this agent instead of gunpowder, would be limited almost entirely to the first cost of the apparatus, and would thus produce an immense saving in the Ordnance department; for the fuel requisite for the production of steam, would in no case bear any proportion to the value of Gunpowder.
>
> The shell of the rocket is to be constructed of the best wrought iron, and made sufficiently strong to resist any given pressure that may be desired for discharging the rocket. The expansive force of gunpowder being within 6000 lbs. to the square inch, some idea may be formed of the power which Mr. Perkins calculates on employing, when we state, that by heating water to what is termed a "white heat, or about 1200° Fahrenheit, he increased the expansive force of the steam to more than 50,000 lbs to the square inch! One half of this power would, however, be more than sufficient for projecting rockets.
>
> Mr. Perkins closes the aperture in his new rocket by running into it some fusible metal; which metal at a given temperature (say 800° Fahrenheit) the water becomes liberated, and instantly expands into steam of immense power, discharging the rocket at the same instant.
>
> Mr. Perkins not having made any experiment with this tremendous power on a large scale, and having a patent in progress for the invention, we defer any further account to a future opportunity.

The Perkins Steam Gun of 1825.



A—The bullet chamber. B—The bullet admission lever. CC—The bullet hoppers. D—The gun barrel. E—A screw to tighten the lever B. F—A swivel joint for directing the aim. G—The throttle valve on the steam pipe HH. From *The Glasgow Mechanics' Magazine*, 1826.

The Steam Driven Rocket.



A—The wrought iron rocket. BB—The tail rods. C—The fusible plug. D—The furnace and the cast iron pipe to guide the rocket. From *The Register of the Arts and Sciences*, 1825.

Apparently the steam rocket never got any further than the patent stage but Perkins did pursue the possibilities of the steam gun which had aroused the greatest public enthusiasm, principally because of the advantage and power it would give to England over her enemies, and by others the hope was freely expressed that with such a terrible weapon, warfare between nations must come to an end *communi consensu.*

It is needless to say that the French people viewed the steam gun experiments with a mixture of disdain and apprehension and it was repeatedly stated publicly that this form of weapon was not new to France. In the *Annales des Sciences Militaires* of 1824 it was stated that General Girard was the real inventor of steam artillery[154] ten years before or in 1814. Referring to this claim, *The New Monthly Magazine* said, in 1825, "The General, according to the French, constructed a movable boiler on wheels like a farrier's forge, this supplied steam for six musket-barrels the breeches of which opened at pleasure. A hopper of bullets was placed above them; and on turning a *rounce,* the barrels received the balls and steam at once. And one hundred and eighty were projected per minute. It is doubtful if this Gallic steam gun ever got further than the experimental stage, its revival in the French news at the time of Perkins' experiments in London being no doubt a gesture of French national pride."

As may be surmised, Perkins made a very noisy neighbor with his gun trials in Water Lane amid the staid surroundings of old Fleet Street. And there must have been numerous complaints at the din of exploding steam from apprehensive property owners. The range offered by the limited space of the courtyard at Water Lane proved insufficient and Perkins removed the steam gun, toward the end of 1824, to Regent's Park. He located on the east side, nearly opposite the newly built Colosseum, the interior of which was then being fitted up as a panorama of London by Thomas Horner, the eminent land surveyor. Some two hundred yards south was the Diorama, opened in 1823, which popular form of entertainment attracted large crowds of Londoners and visiting country cousins, a fact which may have influenced Perkins with his showman's instincts, in his selection of a locality to introduce his steam gun to public notice. Regent's Park at this period was a new and most exclusive suburb, the park itself being flanked by noble terraced dwellings and it represented one of the finest residential sections of London. Then into this aristocratic community in the late summer of 1824 came Jacob Perkins and his Jovian steam gun.

The same year that Perkins removed to the Park, saw the first experiments of Golds-

[154] Among the Fitch Papers in the Library of Congress, there is a document accompanied by a sketch describing some experiments made on April 18, 1797, with a steam operated musket, by three Philadelphians, G. Turner, Richard Wells, and R. Storkton. The drawing shows a steam chamber of cast iron shaped like a retort with a gun barrel attached to it by a stop cock. "With 12 oz. of water thirty musket balls were shot with force to mark deeply a pine board at five yards." The pressure used was estimated to be 300 lbs. per square inch. Captain Samuel Morey, 1762-1843, of Orford, New Hampshire, an inventor and practical experimenter with steam engines, obtained a patent for "shooting by steam" January 19, 1819. The details of his machine are unfortunately not available. Steam artillery is of considerable antiquity. Leonardo da Vinci in his note book in that section devoted to warfare, describes the "Architronito" or steam cannon and attributes its invention to Archimedes. An extract from da Vinci's notes reads: "One third of the instrument stands within a great quantity of burning coals, above is the cistern of water which falls into the breech of the cannon through a valve. . . . and when consequently the water has fallen out, it will descend into the heated part of the machine and there it will instantly become changed into so much steam that it will seem marvelous, and especially when one sees its fury and hears its roar. . . . This machine has driven a ball weighing one talent six stadia." A Greek talent is approximately 80 pounds and the distance of six Roman stadia was about three-quarters of a mile.

worthy Gurney with his steam carriage in near by Albany Street. Gurney, a doctor by profession but an engineer by instinct, conducted his dual occupation at the premises of Sir William Adams' eye infirmary, a few doors below the military barracks. The actual locality of Perkins' establishment is not so clearly defined. It was always referred to as the Regent's Park manufactory in the news of the day and in the directory it was stated to be "near the Diorama," and probably was also on Albany Street somewhere between Frederick Street and the New Road. These premises were used at first only for demonstrating the steam gun, but after 1827 the entire business of Perkins and Company moved from Water Lane to the Regent's Park Works, which were occupied until 1832. Between the years of 1824 and 1826, during the height of the steam gun demonstrations, there came, like the pilgrims to Mecca, the flower of the Royal Family, the heads of the army and navy and the titled aristocracy, not to mention the more humble citizens of London.

The whole country was thrilled by this fresh evidence of steam power and the matter became the subject of much jocular comment as well as serious consideration. *The New Monthly Magazine* printed in the early part of 1825 an epic poem entitled "Steam." the eleventh stanza of which is given here, and on the right a picture of Britannia's steam navy which in 1829 appeared in Stuart's *Anecdotes of Steam Engines.*

Britannia's Steam Navy

Five hundred balls, per minute, shot,
Our foes in fight must kick the beam;
Let Perkins only boil his pot,
And he'll destroy them all by steam.

Rear Admiral Lord Exmouth stated during the trials "he believed the time would come, when a steam-gun boat with two guns in her bow, would conquer any line of battle-ship."

An account of one of the principal exhibitions given before the Duke of Wellington and party of artillery officers on December 6, 1825, is thus recorded in the London *Times:*

PERKINS' STEAM GUN.

The neighbourhood of Mr. Perkins' safety steam engine manufactory near the Regent's Park, was on Tuesday thrown into great consternation by some tremendous reports, arising from the discharge of his steam gun. Since a fatal accident, which occurred several months ago, where a lady threw herself from a gig, in consequence, as it was at the time incorrectly supposed, of her horse having taken fright at the prodigious noise made by the steam gun, the terrific engine of destruction had not been permitted to be discharged by the individuals belonging to Mr. Perkins' concern. On Tuesday morning, however, soon after eight o'clock, patroles were observed stationed on all the roads leading towards the manufactory, accompanied by men with placards on boards, warning all passengers on horseback or in carriages, to go through the Regent's Park, instead of proceeding by the high road leading in front of the manufactory.—Soon after nine, numbers of military officers, in carriages and on horseback, alighted at the manufactory. They were soon followed by the Duke of Wellington; and immediately afterwards the discharge of steam, which had been previously occasional, and of comparatively slight force, commenced with a continued roar, resembling the loudest thunder we ever heard. The group of eminent persons then assembled, consisted of his Grace, the Master General of the Ordnance, and his Staff, the Marquis of Salisbury, Mr. Pell, Sir H. Hardinge, Lord Fitzroy Somerset, the Judge Advocate General, and many military officers of the highest rank; together with a Committee of Artillery and Engineer Officers, who, it appeared, had been officially appointed by the Duke of Wellington to examine into the merits of this wonderful specimen of human ingenuity and destructive power. The discharge of steam now became almost incessant for two hours; during which, its incalculable force and astonishing rapidity in discharging balls, excited amazement and admiration in all present. At first the balls were discharged at short intervals, in imitation of artillery, firing against an iron target at the distance of 35 yards. Such was the force with which they were driven, that they were completely shattered to atoms. In the next experiment, the balls were discharged at a frame of wood, and they actually passed through 11 one inch planks of the hardest deal, placed at a distance of an inch from each other. Afterwards they were propelled against an iron plate one fourth of an inch thick, and at the very first trial, the ball passed through it. On all hands, this was declared to be the utmost effort of force that gunpowder could exert. Indeed, we understand that this plate had been brought especially from Woolwich, for the purpose of ascertaining the comparative force of steam and gunpowder. The pressure of steam employed to effect this wonderful force, we learnt, on inquiry, did not at first exceed 65 atmospheres, or 900lbs. to the square inch; and it was repeatedly stated by Mr. Perkins, that the pressure might be carried even to 200 atmospheres with perfect safety. Mr. Perkins then proceeded to demonstrate the rapidity with which musket balls might be projected by its agency. To effect this he screwed on to the gun barrel, a tube filled with balls, which, falling down by their own gravity into the barrel, were projected, one by one, with such extraordinary velocity, as to demonstrate, that by means of a succession of tubes filled with balls, fixed in a wheel, (a model of which was exhibited,) nearly one thousand balls per minute might be discharged. In subsequent discharges or volleys, the barrel, to which is attached a moveable joint, was given a lateral direction, and the balls perforated a plank nearly twelve feet in length. Thus, if opposed to a regiment in line, the steam gun might be made to act from one of its extremities to the other. A similar plank was afterwards placed in a perpendicular position, and in like manner, there was a stream of shot holes from the top to the bottom. It is thus proved that the steam gun has not only the force of gunpowder, but also admits of any direction being given to it. But what seemed to create most surprise, was the effects of a volley of balls discharged against the brick wall by the side of the target. They absolutely dug a hole of considerable dimensions in the wall, and penetrated almost one half through its thickness. We heard several officers declare their belief, that, had the balls been made of iron instead of lead, they would have actually made a breach through it—the wall was 19 inches thick.

The War of Independence begun in 1821 between Greece and Turkey, was then at its height and the Greek envoys in London were soliciting arms and money from Britain to carry on their fight for liberation. Perkins had asserted "that a 36-pounder with all its apparatus, steam boiler, generator, etc. may be drawn about the field of battle, by four or

five horses and discharged with 50 times the rapidity of an ordinary cannon." And it is recorded in one of the issues of the *Gentleman's Magazine* of 1825 that "the Greek committee were very anxious to obtain a few of Mr. Perkins's Steam Cannon, for the purpose of enabling the Greeks to hasten the surrender of Patras, and the other fortresses in Greece, which are held by the Turks; but it is said that they were prevented from obtaining them by a treaty between Mr. Perkins and our Ministry, for the exclusive right to these tremendous engines of destructions."

Samuel G. Goodrich, shortly before his return to America, attended one of the earlier gun trials and his impressions of the occasion, as well as of the inventor himself, are very enlightening. Goodrich did not spare his countryman and is perhaps unduly harsh in his judgment of Perkins' character, but his impressions must have remained unimpaired for Goodrich did not publish his account until thirty-two years later: [155]

> At this period, our countryman, Jacob Perkins was astonishing London with his steam-gun. He was certainly a man of extraordinary genius, and was the originator of numerous useful inventions. At the time of which I write, [1824] he fancied that he had discovered a new mode of generating steam, by which he was not only to save a vast amount of fuel, but to obtain a marvellous increase of power. So confident was he of success, that he told me he felt certain of being able, in a few months to go from London to Liverpool, with the steam produced by a gallon of oil. Such was his fertility of invention, that while pursuing one discovery, others came into his mind, and, seizing upon his attention, kept him in a whirl of experiment, in which many things were begun and comparatively nothing completed. Though the steam-gun never reached any practical results, it was for some time the admiration of London. I was present at an exhibition of its wonderful performances in the presence of the Duke of Sussex, the King's youngest brother, and the Duke of Wellington with other persons of note. The general purpose of the machine was to discharge bullets by steam, instead of gunpowder, and with great rapidity—at least a hundred a minute. The balls were put in a sort of funnel and by working a crank back and forth they were let into the chamber of the barrel—one by one—and expelled by steam. The noise of each explosion was like that of a musket, and when the discharges were rapid, there was a ripping uproar, quite shocking to tender nerves. The balls carried about a hundred feet across the smithy, struck upon an iron target, and were flattened to the thickness of a shilling piece. The whole performance was indeed quite formidable, and the Duke of Sussex—who was an enormous, red-faced man—seemed greatly excited. I stood close by, and when the bullets flew pretty thick and the discharge came to a climax, I heard him say to the Duke of Wellington, in an undertone—"Wonderful, wonderful, d - - - - d wonderful;" then again "wonderful, wonderful, d - - - - d wonderful;" then again, "wonderful, d - - - - d wonderful." And so he went on, without variation. It was in fact, save the profanity, a very good commentary upon the performance.

The only illustration which can be found of the steam gun is shown on Plate XXVII. This exceedingly crude piece of draftsmanship appeared in the *Glasgow Mechanics Magazine* on January 14, 1826. The bullets shown in this drawing are full size and were 0.65 of an inch. At the left is shown the front of the bullet after striking the target and on the right is indicated the reverse side. By referring to the gun itself, CC are the bullet hoppers and B is the handle which admits the bullets one at a time into the barrel D which was six feet long. F indicates a universal joint which allowed the barrel to swing in any direction, up and down as well as laterally. G is the steam valve between the gun and the generator. In a later model [156] the barrel was reduced to 5/16″ diameter bore and the aperture of the

[155] *Recollections of a Lifetime*, Goodrich. Vol. II, pp. 225-227.
[156] From a report on the steam gun in the *Transactions of the Institution of Civil Engineers*, 1842, Vol. III, p. 430.

steam valve enlarged to 5/8″, which was four times the area of the bullet, and prevented throttling of the steam. Over a period of trials, it was found that the lead balls, which were a very close fit, often stuck halfway down the barrel, but on closing the steam valve and then opening it suddenly, the balls were always expelled. This was considered to indicate that it was the velocity of the steam that kept the ball moving rather than the pressure alone which gave power to the ball. In the case of gunpowder, it is the rapidly increasing pressure of combustion which almost instantly propels the ball from the muzzle.

Though the committee of artillery officers appointed by Wellington[157] could scarcely have failed to be profoundly impressed by the evidence of their own eyes, nevertheless it is not surprising that nothing was done about adopting the steam gun officially, even for coast defense purposes. It was considered at the time, 1825, "that steam artillery could not be made any lighter than ordinary cannon and would be useful only for fortifications of a permanent order." Also there was the fact that adequate steam pressure of 900 pounds, which was required to operate the gun, would take at least thirty minutes to raise, even when the fire was urged intensely by means of bellows. This alone would have prevented its adoption as a fieldpiece where instant readiness against surprise attacks was a prime requisite. Perkins claimed that to throw 15,000 bullets per hour for sixteen hours would require 15,000 pounds of gunpowder at a cost of £525 while by steam it would cost not more than £4, but even this estimated saving failed to influence the Government and Perkins was finally forced to let the matter remain in abeyance.

On August 11, 1825, Perkins patented a method for maintaining the tautness of the padding and springs of bedsteads, sofas and chairs, and to prevent the gradual sagging of these from usage he devised a roller at one end by which the canvas underpiece was tightened and held by a rachet wheel. This patent is in strange contrast to those ideas which now so constantly absorbed his mind, having no bearing on his steam problems. One can perhaps visualize that one day Mrs. Perkins complained of the state of the drawing-room sofa and the versatile Mr. Perkins instantly took pen and paper in hand and solved the difficulty as is indicated by his patent. See Plate XXV.

Perkins at this period, 1825, was not without competition in his own field. The progress he had made with flash steam brought forward several rivals with similar inventions. One of these was Major John McCurdy of New York, an American then residing in Cecil Street, London. McCurdy had obtained Joseph Hawkins' patent of 1816 and had come to England to promote it. He repatented Hawkins' injection generator (which has been previously mentioned) on June 15, 1824, and then quickly sold it for a large sum to a small company of gullible speculators. McCurdy's generator measured 11 feet long and tapered from 6 inches to 3 inches in diameter and he claimed that a cubic inch of water injected into the red-hot steam chamber or retort would provide enough steam for one stroke of a four horsepower steam engine. It was found, however, under working conditions that if some

[157] Duke of Wellington (Hon. Arthur Wellesley), 1769-1852. In 1818 he was appointed Master General of Ordnance and in 1826 was Constable of the Tower of London. The Duke had been in virtual retirement from public affairs since 1823 and passed much of his time at Apsley House in London and at his country estate "Strathfieldsaye" in Hampshire. The Duke was already becoming very deaf, a result of his active campaigning. S. G. Goodrich who saw him during the steam gun trial, speaking of his appearance, says: "He was really a rather small, thin, insignificant looking man unless you saw him on horseback. His profile was indeed fine but his front face was meagre, and the expression cold." Wellington himself was unimpressed by the powers of Perkins' steam gun and predicted its failure in warfare.

of the injection water was not vaporized, it passed into the engine with dire results.[158] But this, of course, had ceased to be McCurdy's trouble. Later he designed another boiler having no resemblance in action to the first one. This was patented in December of 1825, but as this boiler was not in any sense an instantaneous steam generator, it is unnecessary to describe it here.

A more serious contender for Perkins' laurels was the invention of Dr. Ernst Alban, a physician of Rostock in Mecklenburg. Through an agent named Raddatz he obtained a patent in 1825 for instantaneous generation of steam. Dr. Alban spent two years in England, between 1825 and 1827, endeavoring to promote his invention but without success. A generator and engine, however, were constructed in London in 1827 and were used for pumping water as a demonstration. Like Perkins, Dr. Alban had to design a special engine which would operate successfully with such pressures of 600 pounds and over. This engine is believed to have been horizontal with two solid plungers in lieu of a double acting piston. Later Dr. Alban, after his return to his own country, reverted to the use of a sturdy type of oscillating engine for his further experiments. So highly was his work considered in this direction by William Pole, the civil engineer, that Pole translated Dr. Alban's elaborate treatise, *The High Pressure Steam Engine,* and published it in two volumes in 1847-8.

The feature of Dr. Alban's instantaneous generator was that the heat was applied indirectly through the medium of a fusible metal such as lead. The heating elements consisted of two rows of pendulous iron tubes closed at their lower ends and at the top opening into a horizontal steam collector. These tubes dipped into two flat boxes, about four feet long and three inches wide, containing the molten metal. Water was sprayed into the upper part of each tube and instantly converted into steam. The furnace was regulated by a small expansion chamber in the molten metal, connected by a pipe to a column of mercury, which actuated a piston and lever controlling the damper. The whole system was well worked out, though the advantages obtained by increasing the heating value of the tubes by means of a fused conducting medium was offset by the frequent fracture of the cast-

[158] The almost insurmountable difficulty of all early injection boilers was in regulating the amount of water supplied, in proportion to the steam requirements of the engine. A cubic inch of water will produce about a cubic foot of steam at atmosphere, and if the pressure in the generator is raised or more steam at a higher pressure is required by the engine, more water must be supplied. It will be seen that in a generator which has to produce the exact amount of steam instantly as required by the engine, the feed pump has to measure out the necessary water with great accuracy or the steam will be furnished at excessive pressures. The generator or retort has also to be kept at high temperature for if it cools down by reason of too much injection, water and not steam is carried into the engine cylinder with the almost certain result of forcing off the cylinder heads. This may be considered as one of the many reasons why Perkins abandoned his first generator in favor of one (1827) which had a small drum to trap the water and equalize the steam pressure to his engine. The early experimenters with flash steam found that the heat of the fire was rarely consistent for long with the injection water or the demands of the engine for steam. Real success with this type of generator only became possible when the passage through the heating elements was made so small that the water was laminated as it were, between the sides of the tube and this prevented spheroidal drops of water from being carried along with the steam as in tubes of large diameter. A situation that was apt to produce sudden and dangerous pressures. Perhaps the most successful flash steam generator to be developed along these lines was that invented by Leon Serpollet in France during the early 1890's. Steam trams and motor cars working at pressures of one to two hundred pounds were in very successful operation in Paris at this period. In addition to using heating elements in which the water passages were of almost capillary dimensions, Serpollet also by means of two separate pumps, operated by sliding cams, exactly proportioned the water and liquid fuel to the varying requirements of power and speed of his engine.

iron boxes, due to unequal expansion between the two metals subjected to the heat of the furnace.

As already mentioned, Perkins visualized many applications for his method of generating steam and one of these was the possibility of revolutionizing existing steam engine practice in Cornwall. About 1825 Perkins had formed an acquaintanceship with Samuel Moyle,[159] a civil engineer from the mining center of Chacewater near Kenwyn in Cornwall. Moyle, a progressive engineer with imagination, no doubt found Perkins' views stimulating and it was arranged by Moyle that a pumping engine on Perkins' plan be given a trial at one of the Cornish mines. A correspondent, whose identity is not revealed, writing to the editor of the *London Journal of Arts and Sciences* in 1826, said: "Mr. Perkins's system of generating high steam has recently been applied to the Cornish single stroke pumping engine, by Mr. Samuel Moyle, civil engineer from Cornwall." This unknown correspondent continued, "Although the engine is not yet complete in all its parts, yet enough has been done to prove its great power and safety." Though no specific location is mentioned, this seems evidence enough that a pumping engine was actually constructed by Perkins and tried out during 1826 at one of the Cornish mines. There is also some further evidence that Perkins paid for most of the work and materials for this engine. In a Perkins and Company ledger[160] was found an entry under date of August 25, 1826, to the effect that they had received at Fleet Street Works from Coalbrookdale Ironworks in Shropshire, "parts for 40 inch pump with working barrel 8 ft. long, total £243." The Perkins engine apparently differed but slightly from the standard Cornish pumping engine, the difference being that the steam cylinder was only 9 1/3 inches in diameter, but with this and a steam pressure estimated to be 35 atmospheres a column of water 40 inches in diameter was lifted 40 feet high. A favorable report on this engine was given by two Cornish engineers, Henry and Josiah Hornblower,[161] who at this time were temporarily in the employ of Perkins in erecting his engine. The testimony of the Hornblowers was reproduced in many of the current journals in 1826 and reads:[162]

> We, the subscribers, have for some time past been employed as practical engineers at Perkins and Co.'s Steam Engine Manufactory, in applying Mr. Perkins' system of generating high steam, to the Cornish, single-stroke, pumping engine, of which we have had nearly twenty years practice. From what we have witnessed, we are perfectly satisfied that no danger can be apprehended from explosions. Its great power is established by the fact of its having lifted a column of water 40 feet high, and 40 inches diameter, with a 9⅓ inch piston. As to the economy of fuel, which is evidently great, we

[159] Samuel Moyle was born in Chacewater, Cornwall, January 17, 1784. Moyle's mother, Julia, was the third daughter of Jonathan Hornblower the elder (1717-1780) whose brother Josiah Hornblower erected the first steam engine in America, at the Schuyler Copper Mine, New Jersey, in 1753. Samuel Moyle's father was the Rev. John Moyle and he was the eldest of seven children. Samuel Moyle erected a number of engines in Cornwall at Wheal Busy in 1811 and at Wheal Charlotte, Wheal Mexico, Beam Mine, Wheal Breage, etc. He also spent a part of his life in construction work in South America. Samuel Moyle died at Bosvigo, near Kenwyn, Cornwall, January 5, 1857.

[160] From an entry in an account book recording materials received by Perkins and Company, Water Lane, during 1826. In the possession of Baker, Perkins and Co.

[161] The Cornish Hornblowers were a large clan, almost all of whom were engineers. The first to come to Cornwall was Joseph Hornblower in 1725 to erect a Newcomen engine near Truro. Jonathan his son (1717-1780) was the most famous of the engineering Hornblowers. He was a stanch Presbyterian and gave all his 13 children Biblical names beginning with J. One of his sons was named Joseph and this one was the father of Henry and Josiah Hornblower.

[162] *London Journal of Arts and Sciences*, 1826, Vol. II, p. 264.

cannot exactly say, owing to some parts of the engine being incomplete, especially the injection pump. The longest the engine has worked at any one time was two hours; at that time it was making 14 strokes per minute, 6½ feet stroke, and lifting a column of water 36 feet high, and 40 inches diameter, consuming not more than 100 pounds of coals per hour. We also certify, that Mr. Perkins' flexible steel piston is quite tight, although, at times, working at a pressure of 50 atmospheres.

HENRY HORNBLOWER,
JOSIAH HORNBLOWER.

An interesting point is brought out by the foregoing testimonial, namely, the frank statement that the engine had never worked more than two hours at a time. The correspondent to the *London Journal*, previously mentioned, stated at that time: "As to economy of the fuel, although undoubtedly great, nothing decisive is yet known, owing to the imperfection of the injecting pump, which occasionally failed in giving the full supply of water, upon which the proper supply of steam wholly depends." It would appear from all this that the experiments in Cornwall upon which so much depended, were most inconclusive, due to poor preparation and incomplete mechanism. Perkins never mentioned the exact location of this trial of his system, but it is traditionally known in Cornwall to this day that Perkins did carry out experiments with very high pressure steam on a Cornish engine at Wheal Busy Mine near Chacewater during 1826.

This mine was the largest of a group of small copper mines situated north of the main highway between Truro and Redruth. It was very old and originally had an early Newcomen engine to pump out the mine. It was here in 1777 that the first of the Boulton and Watt engines was erected in Cornwall. In 1811 a large Watt engine with a cylinder of 66 inches diameter was erected at Wheal Busy and drew water from a depth of 528 feet. By 1826 the comparatively low efficiency of this engine decided the mine adventurers to discard it and buy a Cornish built engine or the best which could be obtained elsewhere. It was because of this that Perkins' engine was given a trial. It is evident that it was only a temporary one and that the engine was not placed over the main shaft, as the great diameter of the pump (40 inches) and the comparatively short lift of the water indicate. The subsequent records of Wheal Busy Mine show that a Cornish engine with a 70-inch cylinder replaced the Watt engine and continued to do duty until the mine closed down in 1828. The Cornish engineers of that day were a close fraternity and as an old saying goes "the county is divided into two classes, Cornish men and Lun'oners." And Perkins from London could not have expected to make much headway with his new system of steam, no matter how successful his demonstrations had proved.

Perkins' further and more conclusive experiments on the compressibility of liquids and gases, which he had made during 1821 and 1822, were finally made public by the Royal Society and a paper prepared by Perkins was read before that body on June 15, 1826, on *The Progressive Compression of Water by High Degrees of Force with some Trial of its Effects on Fluids.*[163] The various pieces of apparatus needed for carrying out these exhaustive tests had represented a considerable outlay in both time and money and various suggestions made by Dr. Wollaston in June of 1820 had been introduced into their construction. The principal piece was a specially made hydraulic force pump which formed, by means of a large screw cap, the cover of a heavy gunmetal cylinder closed at

[163] *Philosophical Transactions of the Royal Society*, London, 1826, Part II, pp. 541-547, with an engraving of the apparatus and a curve chart.

its base. Into this chamber the various piezometers, made of glass and metal, were introduced and so could be subjected to the immense pressure of the water forced in by the powerful lever pump. With this apparatus, experiments on the compressibility of water were made and the results were noted on a graduated chart by a curved line. It was noted that the piezometers used would not indicate with more than 1,000 atmospheres or 14,000 pounds so another piezometer was obtained 8 inches long by ¾ of an inch in diameter. This, after repeated experiments, at still higher pressures proved that a column of water 8 inches long could be compressed two-thirds or one-twelfth of its length by a pressure of 28,000 pounds. With the same apparatus Perkins compressed other fluids, notably acetic acid, which crystallized at a pressure of 15,400 pounds with the exception of one-tenth part which remained liquid. Another experiment showed that air could be permanently combined with water under a pressure of 7,000 pounds. On compressing air alone, Perkins observed that after 7,000 pounds pressure, the air decreased and liquid was formed. In fact, liquid air was demonstrated for the first time. The evidence that gases could be liquefied was first observed by Perkins, he said, in January of 1822. At fig. 3 and fig. 4 on Plate XVI is shown the improved piezometer as used in London. This was a brass tube A, closed at B and C, in which tube water was allowed to enter through the small aperture, e. closed by a valve pressed to its seat by a light flexible spring. The tube was flattened at D so that it might yield to the expansion of the water when taken out of the hydraulic press. The piezometer was completely filled with water and at 326 atmospheres, Perkins found that there was an increase of 3½ per cent in the water. Though public acknowledgment of these extremely important experiments made by Perkins during 1821 and 1822, was long withheld from the scientific world, thus minimizing to some extent the credit of priority, the record indelibly remains.

The years of 1825 and 1826 were difficult and disastrous for all business enterprise and it is a matter of wonder how Perkins could have found the money necessary to carry on his lavish experiments with his steam engine. That he largely depended on capital supplied by enthusiastic partisans is almost certain but after the widespread industrial depression which had now set in, this must have been seriously curtailed. The money panic of these years, due largely to the rise in commodity prices in 1824 and to the excessive issue of paper money by the Bank of England, as well as by the majority of country banks in the industrial centers, seriously decreased all private enterprise. It has been made evident that Joseph C. Dyer was in the beginning a considerable financial factor in the engraving business carried on in Fleet Street but there is nothing definitely known as to whether he also contributed any of the money necessary for the continuation of the steam engine experiments. Dyer had always evidenced considerable interest in the use of steam for transporation, at first for steamboats and later for railways, but on this premise alone it would not be safe to say that his friendship for Perkins would have extended to any practical aid in this direction. At this time Dyer was established at No. 8 Stanley treet, Manchester, as a manufacturer of wire cards and machinery, for which he had obtained several patents between 1811 and 1825 and he was now fully involved with his own financial affairs. The objection of the firm of Perkins and Heath to shouldering any part of the expenses of the Perkins and Company manufactory is already a matter of record. The engraving plant itself had done remarkably well in the past years, but the banking crisis must have seriously curtailed a very important part of their business. For

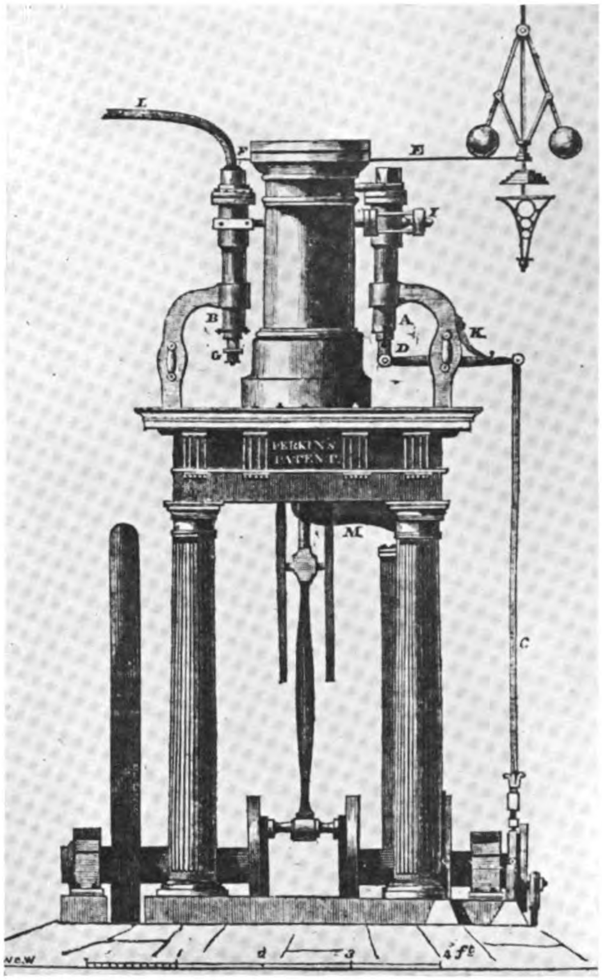
it is recorded in the parliamentary report of February, 1826, that "in the four months preceding 59 banking-houses and 20 other banking establishments had been declared insolvent." Every succeeding week continued to add from seventy to a hundred merchants, traders, and manufacturers to the bankrupt list, for this was a period of bubble speculation, and unprecedented commercial embarrassment and ruin. Where the money came from for so much lavish experimental work is a matter of speculation, for no reliance can be placed on the newspaper statements of fabulous sums paid for fractional shares in the steam engine patent. That Perkins was receiving certain royalties and profits from the engraving business seems reasonable, but that such income did more than pay for his domestic expenses is unlikely. There were indeed at this period many wealthy American men of business, especially shippers, who welcomed the possibility of speeding their trading vessels by such powerful means as Perkins' steam engine appeared to offer. For these were the halcyon years (1820-1830) of American shipping, aided by the protective tariff, ships of the United States were then carrying more than ninety per cent of the Atlantic and other ocean trade. A few account books of the firm of Perkins and Company are still in existence which date from this period, 1825, and these reveal that while a great deal of business was done, not any profit accrued. It may be conceded that such inadequate records do not prove anything very conclusively, but taking these in conjunction with the printed opinions of that day as to the progress of Perkins' engines, it may be deduced that few, if any, went into commercial use in factories, steamboats or mines. Angier March Perkins, who assisted his father during these years of experimentation, says in his private memoirs: "The steam engine business did not succeed and we were obliged to give it up." From this statement it may well be inferred that while Perkins contributed greatly to the theoretical and practical knowledge of steam, he failed to apply it in a manner that could be advantageously adopted into the commercial world.

In April of 1827 Perkins received the news of the death of his old friend and business associate, Gideon Fairman, who passed away in Philadelphia on March 18th at his home at 326 Chestnut Street. Fairman was a colonel in the Light Infantry Corps of the Washington Grays and also an academician of the Pennsylvania Academy of Fine Arts. After Fairman's death there were long and laudatory obituary notices of his work and his business activities as an artist and engraver, but in none of these is any mention made of his recent business affiliations with Jacob Perkins in London.

Perkins was now obliged to turn to other methods of construction by reason of the continued disappointments he encountered in making his steam engine and generator fulfill what had been anticipated from it merely by employing extremely high pressures. It had been found that the superheated steam played havoc with all the internal moving parts of the engine, built as it was along the usual and conventional lines. Perkins eventually realized that he would have to evolve something radically different to eliminate the tortuous passage of the steam through the many small openings of the distributing valve and cylinder ports which extracted the heat without giving any corresponding pressure efficiency. The outcome of all this was an engine of outstanding originality and the first of a type known to engineers the world over as the uniflow engine. A diagrammatic view of a modern horizontal engine of this type is given on page 121 to illustrate the principal difference between it and the more usual form of steam engine.

Perkins' first experiments with the uniflow engine probably date from 1825 and, as first

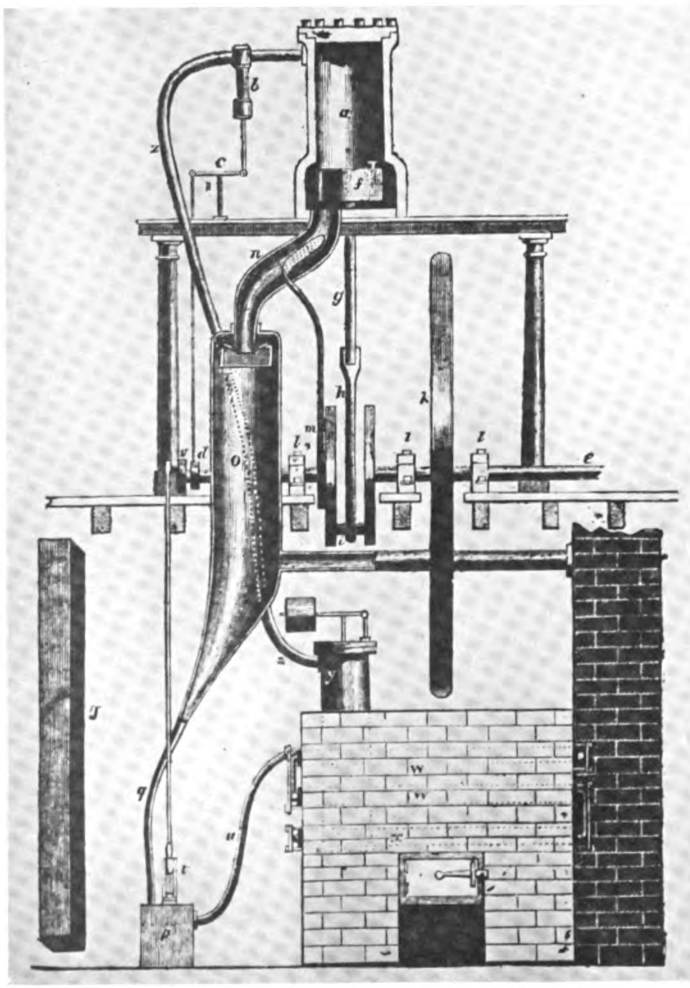
The Single Cylinder Uniflow Steam Engine, of 1825-1827.



The classical lines of Perkins' Uniflow Engine as redesigned by Christopher Davy. From the *Mechanic's Magazine*, 1827.

L —The steam supply.
FBG—The throttle valve.
AI —The admission valve.
DKC—The operating mechanism.
M —The condenser.

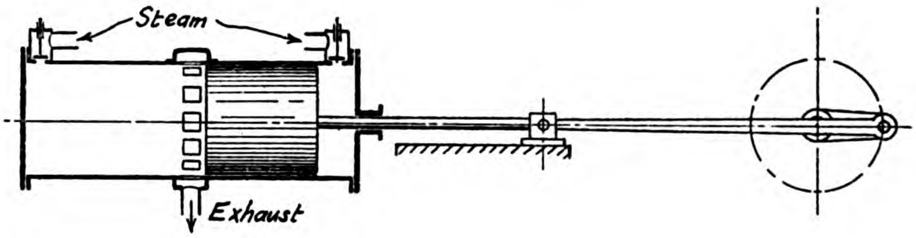
The action and construction of this engine is described in the text.



Sectional drawing of Perkins' first Uniflow Steam Engine. From the *Register of the Arts and Sciences*, 1827.

a —The cylinder.
bcd—The admission valve and mechanism.
f —The piston and equilibrium valve.
gh —The piston and connecting rods.
e —The crankshaft and bearings l l l.
m —A cam for operating the water spray in the condenser n.
o —The expansion chamber containing the non-return valves at the foot of the condenser n.
q —A pipe leading to the hot well p.
t —Injection pump driven from the crank v.
u —The water pipe to the upper tubes ww of the generator.
x —The lower tier of tubes from which the steam passed into the chamber y.
zz —The steam pipe leading to the admission valve b.

built, it was in the form of an inverted single cylinder engine,[164] entirely different in every way from the horizontal machine of 1823. On Plate XXVIII is shown in section the first uniflow engine. The steam generator was apparently placed below the floor of the engine room and the steam was piped up to the admission valve at b., worked by the cam d. and the rocker arm c. This arrangement of the engine and generator seems logical, as the expansion chamber o. of the condenser had to be prolonged so far below the foundation of the engine. As indicated on the drawing, the piston has completed its stroke and the steam, which has forced it downward, escapes past the enlargement of the cylinder bore into the chamber n., there meeting a spray of water injected by the pump m. The condensed steam passed on down through two flap valves into the hot well which supplied the force pump at p. and so was returned to the generator. As will be observed, this engine was single acting and required a very heavy flywheel to equalize the sudden and violent thrust of the steam at the opening of the admission valve. To enable the piston to return to the top of the cylinder, an equilibrium valve f. was placed in the piston. This valve opened by striking the lower piston head and it closed again by contact with the upper one. The spindle of the valve was made friction tight by a flat spring to enable it to stay open while the piston was ascending. It was very quickly found that a piston which had to pass in and out of the cylinder bore could not be successful with expanding metallic rings as used in the horizontal engine of 1823. Perkins was thus forced to use a solid piston of cast iron turned to a very close fit. This in the absence of any means to compensate for wear, proved leaky and troublesome. The necessity of using metallic packing was indeed obvious with such high pressures, and Perkins again reverted to his earlier type of self-lubricating metallic piston



[164] The uniflow engine takes its steam at the end of the cylinder in the usual way but it exhausts it through a ring of ports after the piston has traveled its allotted stroke, the steam passing always in the same general direction, i.e., one way flow. After Perkins had demonstrated the possibilities of the uniflow engine nothing further at the time was done toward improving it. In 1843 George and John Rennie applied the uniflow principle to two locomotives built for the London and Southampton Railway but they were not a success. The development of this type of engine was retarded mainly by mechanical and lubrication difficulties, due to the high pressures and high temperatures involved. The uniflow engine was practically forgotten until the advent of L. J. Todd's patent of June 16, 1885. In this is described a double acting cylinder with the exhaust ports in the middle and two slide valves to admit the steam alternately to each side of the piston. It was not until after 1900 that the uniflow engine was again revived in Germany by Prof. Johann Stumpf. After 1909 engines on this principle were built by Sulzer Brothers in Switzerland and by John Musgrave and Sons, Ltd. in England, and little attempt was made by them to standardize the design. In later years, the uniflow engine has been applied over a wide range of service and load from 20 h.p. to 7,000 h.p. One engine in a rolling mill at Youngstown, Ohio, has a cylinder 60 inches diameter working at a pressure of 140 pounds and 90 to 100 revolutions per minute. The indicated horsepower is 6,800. The early difficulties found in this type of engine are now overcome by forced lubrication and by boring the cylinders with a slight double taper to approximate a parallel bore when heated. There are three types of engines now in use; the uniflow engine, back pressure engine and the steam extraction engine. The comparatively low pressures used in modern uniflow engines are in significant contrast to those advocated by Perkins in 1827.

with three rings. This was made possible by the elimination of the counterbore in the cylinder by a simple process of machine work as shown in the specification drawing of the improved uniflow engine which was patented by Perkins March 22, 1827.[165] The composition of these self-lubricating pistons and rings, as given out by Perkins at this time, was twenty parts copper, five parts tin and one of zinc and this combination was cast under the pressure of a considerable head of metal to produce density. This particular alloy had been first employed for the journals of Perkins' roller presses in 1820 and had been found when used in contact with the cast iron axles of the rollers, to resist wear and to require little or no lubrication.

On Plate XXVIII is shown the exterior appearance of the improved uniflow engine, the classical design of which was due to the draughtsmanship of Christopher Davy of No. 11 Furnival Inn. At this time, Davy was a teacher of architecture and perspective drawing at the London Mechanics' Institute. Of this engine, Perkins said:

> To make the design of these engines appear somewhat more classical, I have erected the cylinder upon a stand supported by four columns and entablature complete of the Roman Doric order.

The engine, from the floor to the top of the entablature, was 5 feet 8 inches high and the cylinder was 8 inches in diameter with a 20-inch stroke. The piston rod was made extremely stiff, being 2¼ inches in diameter. The steam pipe was of copper, 1½ inches external diameter. The flywheel weighed 8 cwt., and was 8 feet in diameter. There is a record in the firm's account books of November 26, 1825, which says that the casting for this wheel cost £9-13-3. After Perkins' new patent of 1827 had been sealed this engine "was open for inspection to the public every Saturday at Water Lane," where it ran under steam, supervised by the inventor. This same plant was later erected at St. Catherine's Docks to demonstrate there its possibilities as a pumping engine.

The specification of the 1827 patent included a drawing of a compound cylinder engine which Perkins called his "double single stroke safety engine." The high pressure cylinder a. of this engine shown on Plate XXX was eight times less than the capacity of the low pressure cylinder A and the stroke of both pistons was twice the diameter of the bore of the high pressure cylinder. To enable the steam to pass without shock from the high to the low pressure cylinder, the crank of the latter was advanced several degrees ahead so that the low pressure crank would be already over the dead center at the moment the exhaust ports of the high pressure cylinder were uncovered. It may be observed in the specification drawing that the objectionable feature of the piston passing clear out of the bore to exhaust the steam, was overcome by drilling a series of vertical holes partially in the cylinder wall, the solid part so left forming an effective guide for the piston and rings throughout the stroke.

On this engine the piston rod glands as well as the pistons were fitted with Perkins' patent metallic rings[166] and were very heavily constructed to withstand the enormous

[165] In this same year Perkins took out French patents covering both the single and compound uniflow engines, dated December 7, 1827. The late Mr. Loftus P. Perkins of London had in his possession the original Dutch letters patent granted to his great grandfather, Jacob Perkins, in 1823. This document is based on the British steam engine patent of 1822 and "certain improvements" patented in 1823. A Dutch patent at this time cost 150 guilders or about £12.

[166] Perkins' flexible metallic packing for pistons as used on his first engines, was a matter of necessity and he also found very quickly that a similar form of packing was just as essential for the piston rod. The construction

pressure. For the admission of the steam, the usual rod valve shown at M was used and steam was cut off at one-eighth of the stroke in the high pressure cylinder. The steam after pressing up the small piston escaped through the upper drilled ports and pressed down the large piston, finally escaping by means of the exhaust ports at the lower end of the cylinder. From here the steam passed to a condenser on the same general plan as that used on the vertical single cylinder engine. The turning effect of the two cylinders was only equal to a double acting cylinder of ordinary construction. Weighted relief valves, one of which is shown at H, were fitted on each cylinder to prevent any trapped water from rupturing the cylinder covers. Of this particular type of engine, only one seems to have been actually made and at some of the impressive demonstrations given by Perkins at his own factory, it is said that steam as high as 1,400 pounds was often used.

For these uniflow engines, Perkins designed a generator along entirely different lines, as shown on Plate XXIX. The coil and pot generator of 1823 was abandoned and a nest of horizontal pipes was substituted. These pipes were connected to a combined water and steam drum and in this feature Perkins could no longer claim the absolute safety from explosions which was the crux of the earlier type, for this steam drum contained a potentially dangerous amount of live steam. By referring to Plate XXIX, it will be observed that there are three tiers of heating elements. These were cast iron pipes 8 feet long and 5 inches square with a passageway of 1½ inches diameter. Water was injected into the two upper rows B and B by the pump N which could be worked by the engine. After preheating the water in these pipes, it passed through the loaded valve shown at C into the lower row of pipes D, which were heated to a cherry-red heat. Upon contact with these, the water was instantly flashed into steam and this was injected into the bottom of the steam drum E, which was partially filled with water up to the level P. The caloric of this red-hot steam was absorbed by the water in the drum and combined to make more steam. The theory of this ingenious method of abstracting heat was described by Perkins in a small printed pamphlet published in 1827, entitled *On the Explosion of Steam Boilers.*[167] Perkins opens up on his subject with these words:

> It has been generally considered a well established fact, that the caloric of steam, at a given elasticity, is invariably the same when in contact with water; but this is far from being the case. It may be, and often is, so generated as to indicate very high degrees of temperature without a corresponding increase of power, so as evidently to prove that temperature alone cannot be relied on as a measure of the elastic power of steam. Many experimentalists have thus undoubtedly been led into error, especially in

---

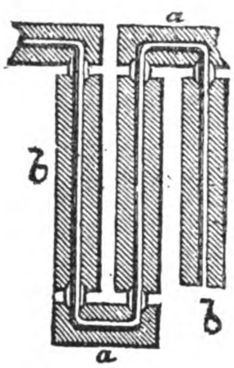
of the metallic rings for the rods on the compound uniflow engine are very clearly shown in the specification drawing and appear to be a smaller variety of those used on his pistons. This was for the times a very advanced step in engineering practice and it is doubtful if this kind of packing was brought into use by engineers again much before 1880. After this period with ever-increasing pressures, superheated steam and higher piston speeds, metallic piston rod packing became a prime requisite, especially on locomotive engines. Charles Frederick Partington, during a lecture given by him September 3, 1825, at the London Mechanics' Institution, produced a 2½-inch diameter piston used by Perkins on his first engine which "consisted of a number of almost entire circles of metals, forming a series of break-joints." Presumably from this Perkins may be considered the originator of the spring piston ring now in universal use on all internal combustion engines.

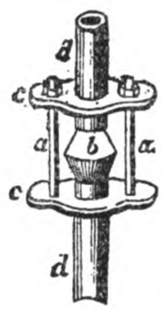
[167] This pamphlet consists of eighteen pages and a folding plate engraved with a diagram showing the relationship of the piston and the crank at various pressures. Perkins was very chary of distributing copies of this pamphlet before his patent of March 22, 1827, was finally sealed, for fear that it might prematurely reveal the nature of his invention. On a copy in the authors' possession, Perkins has written on the margin of the first page: "With the author's compliments. Confidential."

reference to high temperatures. If any part of the boiler which contains the steam be suffered to become of a higher temperature than the water contained in it, for a want of sufficient supply, the steam will readily receive an excess of caloric, and become super charged with it, without acquiring proportional elasticity.

Perkins considered that one of the principal reasons of boiler explosions, which were attributed to an insufficiency of water in the boiler, was due to the superheating of the steam far beyond the temperature of the water. Any sudden agitation of the latter, due to releasing of the pressure too suddenly, would cause the water to foam over the boiler plates already heated to excessive temperature by the steam, thereby flashing into action a dangerous quantity of additional steam. In his pamphlet Perkins cites the case of the steamboat *Graham* which had recently exploded its boiler in the Humber River after twenty pounds had been taken off the safety valve lever. The possibility of overheating the upper plates of boilers by the excessive caloric of the steam was corroborated by Charles Wye Williams, who was at this time manager of the Dublin and Liverpool Steamboat Company. Williams,

Heating elements of cast iron united by a double cone joint. Boiler of 1827. aa — The connecting pipe blocks, united to the ends of the heating elements bb —by double cones.





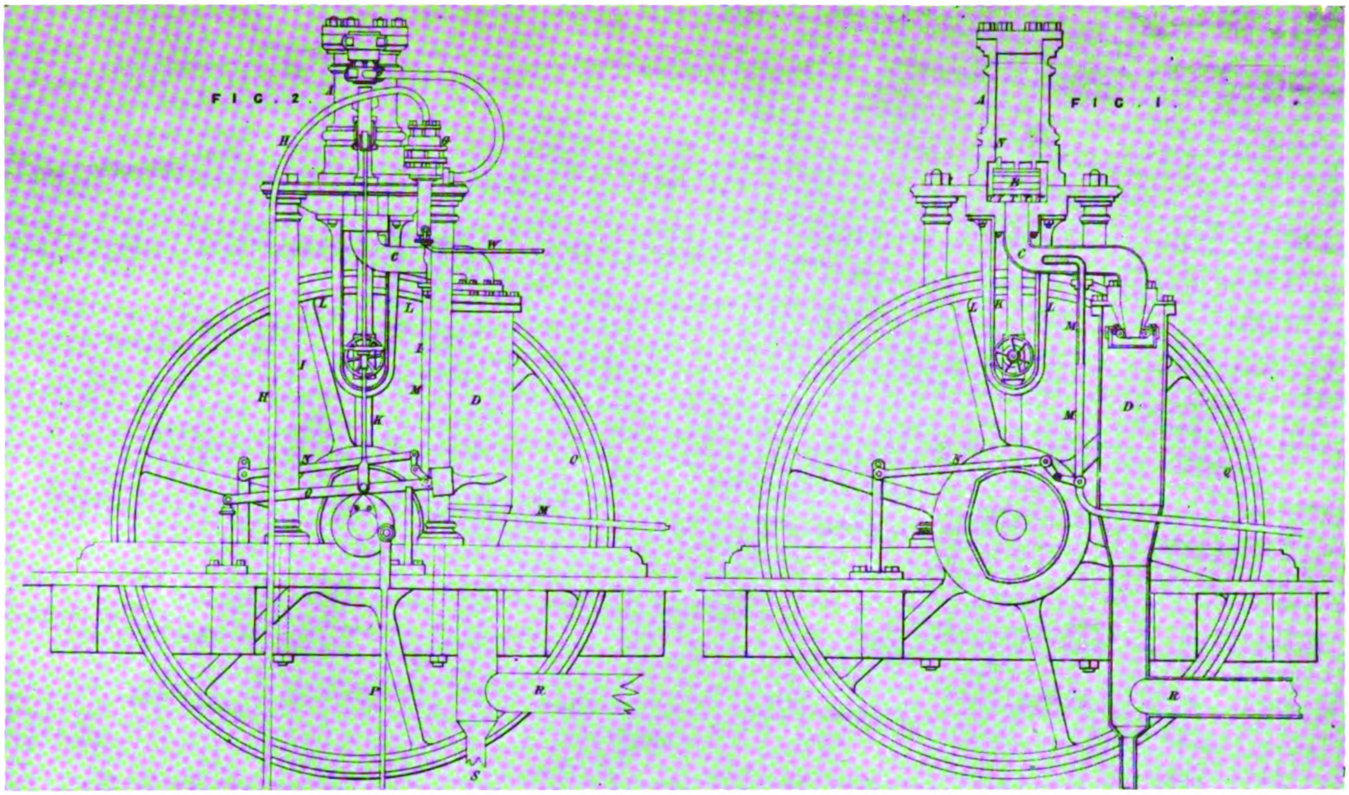
Perkins Metallic Cone Joint for high pressure steam. dd—The pipes to be connected. b—The double cone. aa—The bolts to draw up the flanges cc.

in a communication to Perkins, said that a pine block that had been accidentally left on the top of a boiler on one of the company's steamboats was later found to be on fire, due, he supposed, to this reason. But later in 1861 Williams, in his treatise *On Heat, in Its Relations to Water and Steam*, refutes the possibility of overheated plates being one of the principal reasons for boiler explosions. Perkins, no doubt by deduction based on his recent experiences with his generator of 1823, readily accepted the theory of excessive caloric in the steam as a source of great danger in low pressure boilers.

In this particular pipe boiler of 1827, Perkins completely reversed his previous practice, the essence of which was the safety provided by a small generator containing water only from which the steam was produced as it was required. With the new generator, a large proportion of its capacity was devoted to live steam alone and the method of injecting directly into a tier of red-hot pipes savored too much of McCurdy's gusty retort generator with all its uncertainty of action and liability of deterioration to the cast iron elements.

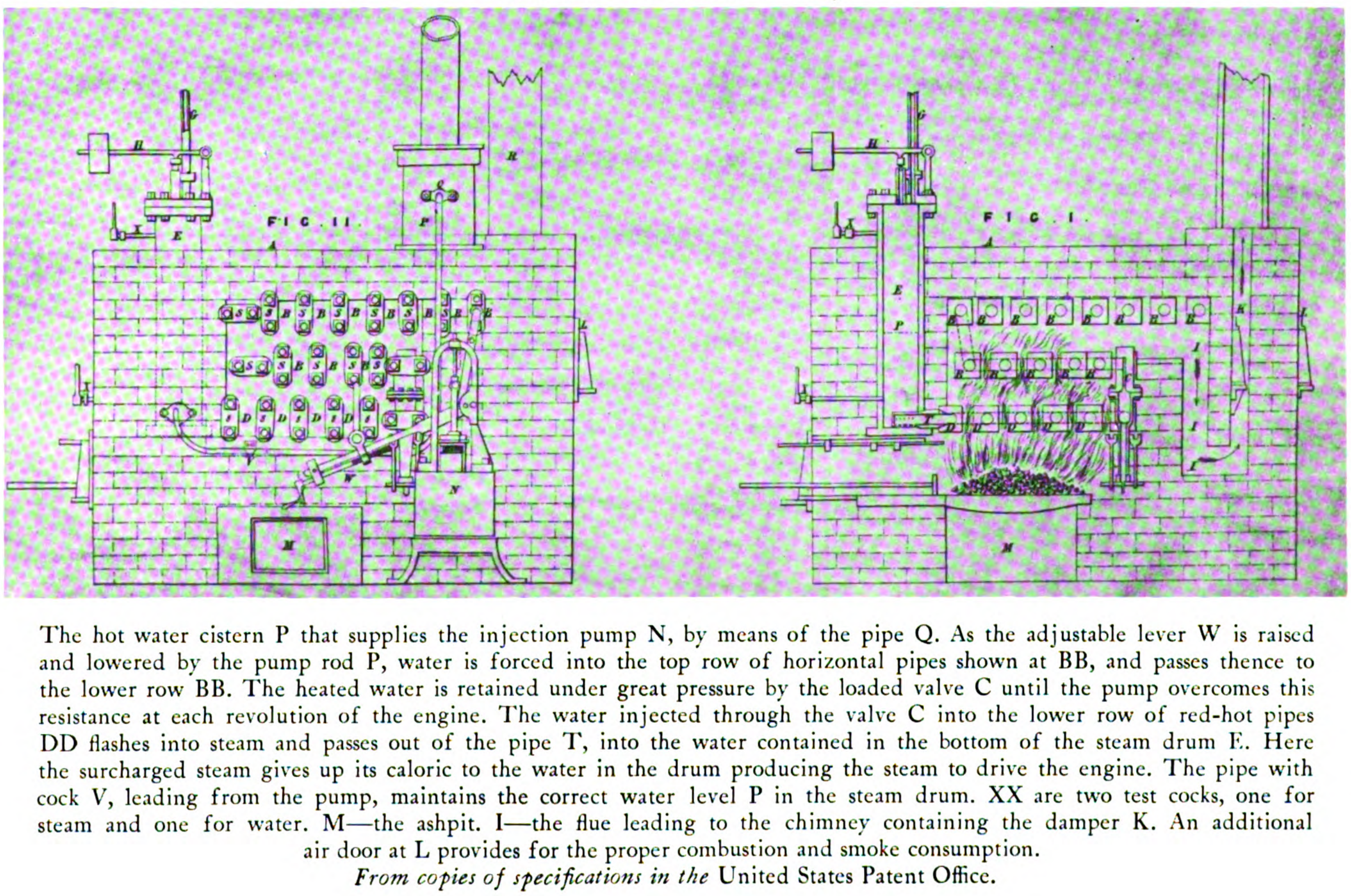
Shortly before the patent for the uniflow engine was sealed, Perkins wrote to his friend and one-time partner, Dr. Thomas P. Jones in Philadelphia, a most astounding letter. It appears to have been written by Perkins in installments and at the peak of his most optimistic outlook regarding the future of his steam engines. The original letter cannot now be traced, but fortunately Dr. Jones considered it at the time important enough to have

The Improved Single Cylinder Uniflow Steam Engine of 1827.



A—The cylinder. BN—The piston and equilibrium valve. TT—The exhaust ports leading into the condenser C, containing the spray fed by the water pipe MM, regulated by a cock operated from the large cam by the rod N D—The expansion chamber containing the non-return valves at the foot of the condenser. At the lower end of the expansion chamber is the waste steam pipe R, and the pipe S to supply the injection pump with hot water. P—The pump rod worked by a disc crank from the engine. HH—The steam pipe and throttle G F—The admission valve operated by the cam and lever O KK—The piston and connecting rods. LL—The crosshead guide with rollers and Q—the flywheel.

The Steam Generator of 1827.



The hot water cistern P that supplies the injection pump N, by means of the pipe Q. As the adjustable lever W is raised and lowered by the pump rod P, water is forced into the top row of horizontal pipes shown at BB, and passes thence to the lower row BB. The heated water is retained under great pressure by the loaded valve C until the pump overcomes this resistance at each revolution of the engine. The water injected through the valve C into the lower row of red-hot pipes DD flashes into steam and passes out of the pipe T, into the water contained in the bottom of the steam drum E. Here the surcharged steam gives up its caloric to the water in the drum producing the steam to drive the engine. The pipe with cock V, leading from the pump, maintains the correct water level P in the steam drum. XX are two test cocks, one for steam and one for water. M—the ashpit. I—the flue leading to the chimney containing the damper K. An additional air door at L provides for the proper combustion and smoke consumption.

From copies of specifications in the United States Patent Office.

it printed verbatim in the journal of the Franklin Institute. At this time, 1827, Dr. Jones was professor of mechanics at the recently founded Franklin Institute on 7th Street below Market. He was also editor of the *Franklin Journal* and it may be supposed that of all people in America, Dr. Jones would have been the best informed as to Perkins' work in London. That the rest of the scientific world was also on the qui vive of interest and excitement may be readily gathered from the contents of this letter:

London, March 8th, 1827.

My Dear Friend,—You must attribute my not having written to you at an earlier date, not to want of inclination, but to a desire of being able to communicate the information which I now give you, namely, that my most sanguine expectations are realized, and to the utmost, in the completion of my *High pressure, safety engine.* This I should have been enabled to say, long since, had it not been for the opposition which I have encountered from avaricious, and interested individuals, by whom my course has been retarded, much more than it has by mechanical difficulties, although these have been enough, in all conscience.

Many of my friends, and some of them very scientific men, have expressed great fears, that I had attempted impossibilities; and were of opinion, that steam engines were so well understood, as to leave little that is new, on this subject, to be discovered. I will ask you, and I will allow no one to be a better judge, if it is not new to generate steam of all elasticities, from the minimum, to the maximum, without the least danger? If it is not new, in the generation of steam, to substitute *pressure,* for *surface,* which I consider the basis of my invention? If it is not new, to have a pressure of 1000 lbs. to the square inch, on one side of the piston, while on the other side of it, all resistance is taken away by a vacuum, and this produced, without an air-pump, or any more water, than is used, in generating the steam? If it is not new, to have invented a metallic piston, which requires no lubrication, and yet is as tight as the piston of an air-pump? If it is not new, to have applied Sir Humphrey Davy's zinc protectors, to steam cylinders, to prevent oxidation? This, I found, took place in my cylinders, when the engine was not at work, after I found that I could dispense with oil. If it is not new, to dispense with the *eduction valve,* and *eduction pipe,* having no other than a small induction valve, and that, so constructed, as to neutralize the pressure, requiring no oil, and very little power, to open, and close it? If it is not new, to allow the steam to escape, at an opening, 250 times larger, than the steam pipe? All this has been effected, as our friend Lukens can avouch, he having witnessed all these facts, as well as myself. And lastly; if it is not new, to have discovered, that steam may be generated, although in contact with water, at all temperatures, without producing corresponding elasticity?

As soon as my last patent is specified here, I will forward it to you, together with the drawings, not only for your inspection, but with a request, that you will forward them to Washington; as a petition to obtain a patent, will accompany them.

I herewith send you a paper, "On the Explosion of Steam Boilers, &c." This paper I have not yet published here, as it might lead to the discovery of my method of correcting the evil arising from generating surcharged steam, before my patent is specified; but as this will be secure, in a very short time, you are requested, if you approve it, to publish the paper in your interesting journal, as I am anxious for its early appearance in my own country. I have, in confidence, given a copy to Dr. Wollaston, to Mr. Faraday, and to several engineers, whom I could trust, and who all agree, that it assigns the true cause of explosions. I long to see, and to converse with you, and my other really scientific friends in the United States, on this, and other interesting points, connected with my engine.

I have had much interested opposition to contend with, since my residence here; but some of the best men in the country have constantly stood by me, or I must have sunk under the pressure. This government have now given the stamp business, to Perkins and Heath, which we should long since have had, and the country thereby have been saved thousands, but for the intrigues of an individual, who is now *sent to Coventry.*

More than a dozen projectors have attempted to make tubular boilers, since I commenced my experiments, of generating steam by small quantities of water, *under pressure;* but for want of pressure, (which is the novelty I claim in my patent,) they have all failed. M'Curdy from New York, who brought out Hawkins's project, was the first who opposed me. He stated, that I had stolen Hawkins's

invention, and gave an air of probability to his assertion, by producing such evidence, from the United States, as he hoped would substantiate it. Yet he was altogether ignorant of my method of generating high steam; and indeed there are not, at this day, ten persons in the world, who are wholly acquainted with it. M'Curdy took out a patent in this country, and sold to the amount of ten thousand pounds; reserving one-third to himself. He has made three small steam boats; one, large enough to take passengers to Richmond, but no one of them ever steamed more than three miles an hour. The quantity of coal consumed, I could not learn; it must, however, have been too great to answer, had there been no other objection, and they have all been abandoned. Of all the methods yet contrived to generate steam, this was the worst. Had the agent in this business, been considered as the representative of the mechanical talents of his country, it would have been most unfortunate; but such is not the case, as there are now here, four Americans, who stand confessedly pre-eminent, viz. Mr. Lukens of Philadelphia, Mr. Wright of New York, Dr. Church, and Mr. Dyer of Boston.

Brown's vacuum engine, has at length given over, although its death was a very hard one. It was, at last, found, that although, at the beginning of the stroke, the mercury showed a vacuum equal to twenty inches, yet his rarefied air became, towards the end of the stroke, more dense than the atmosphere, and there was, consequently, a great loss from its re-action. I had frequently predicted, that this would be the case, and am apprehensive that Morey's explosive engine will be unavailable, from the same cause.

Brown has certainly shown great ingenuity in the variety of mechanical contrivances which he has invented, in order to overcome the difficulties with which he had to contend; his engine was a beautiful piece of mechanism; its appearance was such as caused it to operate like a charm on his numerous visiters, and many were, consequently, induced to take an interest in, and expend large sums of money, to perfect, an instrument from which they calculated to derive large profits. Is it not astonishing, that men of intelligence should not quickly perceive the difference, between condensible steam, and incondensible air? I have already remarked, that at the beginning of the stroke, the barometer indicated a high degree of exhaustion; it sometimes rose to twenty-four inches, yet his piston, if made to approach the end of his cylinder, as closely as in a well made steam engine, could not, from the density of the contained air, pass the dead point. His first engine, you know, raised water ten or twelve feet high, and this was employed to drive a water wheel; in this arrangement, he did not discover how soon his rarified air lost its power; but when he endeavoured to make his engine work with a piston, he began to experience this unanticipated difficulty. By a very clever contrivance, he, *apparently*, overcame this obstruction, but not without great waste of gas. He attached to his engine, a large separate condenser, in which he burnt his gas, professedly, for the greater convenience of condensation; but it was, in effect, nothing more than lengthening his cylinder, which would have produced the same result in a way much more simple; but to have had a ten foot cylinder, with one foot stroke, would, at once, have torn off the mask, by which the true features of the contrivance were concealed; a catastrophe, which the inventor, very naturally, endeavoured, as long as possible, to avoid. The consumption of gas was enormous; but as he made his own, or drew it directly from the city pipes, no one but himself could tell, how much he used.

Fascinated with the beauty of the machine, there are many who, yet, declare it to be no failure, and that Brown has been used very ill by the *Gas-engine Company*. One gentleman, who had lost much money in this concern, called on me the other day, and expressed great regret that the gas-engine had not been in my hands; I told him that this would have produced but one advantage, that of having lost less money by the concern, as it was not from want of mechanical skill, that Brown did not succeed, but because the laws of nature were against him; that I was pursuing experiments in accordance with those laws; and that in this consisted the difference in the results to be anticipated from his labours, and from mine. This gentleman expressed much surprise, when I explained to him the difference between condensible steam, and incondensible air.

I am now engaged in building steam artillery, as well as musketry, for the French government. The English government would certainly have adopted this invention, had it not been for the gratuitous and false statements of certain engineers, who declared, that although I was able to make a great display at the public exhibition, made by order of government, yet it was delusive: that I had never made a generator which stood for a week, and that I could not keep up the steam for more than two, or three,

minutes at one time. These statements obtained credit, the more readily, as any improvement in the art of war, which could be adopted by other powers, and which would have a tendency to place the weak, upon a par with the strong, appeared likely to benefit other countries, more than England.

The French government have determined to give our new system a fair trial. A series of experiments have been made at Greenwich, which were attended by the French engineers appointed for that purpose, by the duke d'Angouleme, together with one of his aids, and prince Polignac. Their report was so satisfactory to the French government, that a contract was immediately made. An English engineer of the first class, and one who is very much employed by this government, has joined me in the guarantee of the four points, which some of the English engineers have doubted; namely, the perfect safety of the generator, its indestructibility, the ability to keep the steam up, at any required temperature, for any length of time, and its great economy.

The piece of ordnance is to throw sixty balls, of four pounds each, in a minute, with the correctness of the rifled musket, and to a proportionate distance. A musket is also attached to the same generator, for throwing a stream of lead from the bastion of a fort, and is made so far portable as to be capable of being moved from one bastion to another. This musket is to throw from one hundred to one thousand bullets, per minute, as occasion may require, and that for any given length of time. It was an observation made in my hearing, by his grace, the duke of Wellington, that any country defended by this kind of artillery, would never be invaded, and I am very confidently of this opinion.

As soon as this machine is completed, it is to be exhibited to this government, and to several engineers from other powers, who are over here, for that purpose. I have no fears for the result, neither has Mr. Lukens, since he witnessed the experiment made for the French government. He saw the steam gun discharge at the rate of from 500 to 1000 balls per minute, and the steam blowing off at the escape valve, during the whole time; he is equally confident with myself, that the steam may be kept up in such a manner as to discharge a constant stream of balls during the whole day, if required. As regards economy, I am within the truth, when I say that, if the discharges are rapid, one pound of coals will throw as many balls as four pounds of powder.

It has been stated, as an objection to the steam gun, that it would take too long to get up the steam, in case of an attack. To this I answer, that a very small quantity of fire will keep the generators sufficiently heated, when there is no water in them: and that when there is any chance of their being suddenly wanted, they should be kept heated in this way. The heat of the generators would last long enough to give off steam; until the fire is sufficiently increased to furnish a constant supply. For naval purposes, this cannot be an objection, as the steam must always be up. Lord Exmouth, after witnessing a few showers of lead, observed, that he believed the time would come, when a steam gun boat, with two steam guns in her bow, would conquer any line of battle ship; and sir George Cockburn said, that the mischief of it was, it would be to nations what the pistol was to duellists, it would bring all, whether strong or weak, upon a par.

To prove the safety of my engine, I have worked it under a pressure of 1400 lbs. to the square inch, or at a hundred atmospheres, and cut off the steam at one twelfth of the stroke; this was merely to manifest what could be done with perfect security. My usual pressure is 800 lbs. per inch, cutting off at one-eighth, and letting the steam expand to below 100 lbs. per inch. I let off at the dead point, at one flash; the manner of doing this I long to explain to you, but must first get my last patent sealed.

I am informed that our friend, Dr. Hare, thinks I have ventured beyond my depth; in this he is not singular, nor do I wonder that such an idea should prevail, after the publication of so many absurd things respecting my engine; I had no knowledge of these publications, and of course had no control over them. Indeed, I have been extremely cautious about publishing any thing myself, or sanctioning it in others; my determination having been first to complete the *essential* improvements of which I have been in pursuit. I presume that you have seen my last paper on the compression of water, air, &c. Its publication by the Royal Society, has created no small sensation among the philosophers of the old school. The council would not have allowed the reading of it, had not Dr. Wollaston and Sir Humphrey Davy witnessed many of the experiments. I shall soon publish an experiment with which I think Dr. Hare will be pleased, as it will, if I mistake not, prove practically, what the doctor has so ably attempted to establish theoretically, namely, that caloric is matter. The proof is simple and direct, and I am persuaded that, when you see it, you will think it conclusive. I was led to the discovery of this

fact by my experiments upon steam; the results of many of which have been very extraordinary, and quite unexpected. One of the most striking, is the great repellent power of heat. I discovered that a generator, at a certain temperature, although it had a small crack in it, would not emit either water, or steam. This fact I mentioned to a very scientific friend, who questioned its accuracy, and to convince him, I tried the experiment; but he concluded that the expansion of the metal must have closed the fissure. To remove every doubt, I proposed to drill a small hole through the side of the generator, which was accordingly done. After getting the steam up to a proper temperature, I took out the plug, and although we were working the engine at thirty atmospheres, nothing was seen, or heard, to issue from the plug-hole; all was perfectly quiet; I next lowered the temperature, by shutting the damper, and opening the furnace door; a singing from the aperture was soon observable, and when a coal was held before it, rapid combustion ensued; nothing however was yet visible; but as the temperature decreased, the steam became more and more visible, the noise at the same time increasing, until, finally the roar was tremendous, and might have been heard at the distance of half a mile. This was conclusive. I should mention that, at the aperture, the iron was red hot.

My belief is, that water cannot be brought into contact with iron, heated to about 1200°, without a force equal to the maximum pressure of steam, which is equal to about 4000 atmospheres, when water is heated to about 1200°. That pressure, would, I believe, keep it in contact with iron at any degree of heat, and the steam would then be as dense as water. It is very evident that if it would require that force to keep the water in contact, heated as it was at the vent hole, thirty atmospheres must be insufficient to effect this: but the experiment affords some data towards answering the question, at what distance from the heated metal the water remained, when under the pressure of thirty atmospheres? We may safely aver, that it exceeded one-eighth of an inch, as the hole was one quarter of an inch in diameter.

After commencing this letter, I ascertained that my patent was likely in a few days to pass the great seal, and have delayed forwarding it, until I could give you some account of the effect upon the minds of those engineers who were open to conviction, of an experiment performed before them. The patent has been sealed, and the engine has had its power, and economy, tested. The result has been so satisfactory, that an engineer, who employs, at least, 300 hands, has taken orders to make engines, (for I license them out,) with the following guarantee, viz. that of saving half the fuel, and three-fourths of the weight and bulk, with less liability of derangement than ordinary engines. This engineer, whose name is Penn, and who is frequently employed by government, is now making an engine for steam navigation, with a *nine* inch cylinder, and *twenty* inch stroke; he joins me in guaranteeing it to be of sixty horse power. It will not occupy more than *one-sixth* of the room, nor exceed *one-sixth* of the weight, of the ordinary Boulton and Watt's engine, of the same power.

I have sent you the last "London Journal of Arts, &c.," which contains some account of my engine, which is nearly correct as far as it goes. It should, however, have stated, that the piston was eight inches in diameter, that it was a twenty inch, single stroke, engine, a good seventy horse power, and consuming but one-fourth of the coal, of a condensing engine. The weight on the end of the lever was three hundred, instead of one hundred and fifty pounds.

You may, my dear sir, depend upon what I have written; it is the result of actual experiment, and there is no fallacy in it. Having succeeded in making a piston which requires no oil, I am determined to ascertain the limits to which pressure can be carried. I am now making a small engine, strong enough to bear 2000 lbs. per inch, and when done, you shall know the result. Nothing but the piston will limit the power.

The victory, which I have obtained, has been a glorious one for me. For the last three months, many of the engineers had declared me insane, as I had asserted, that I could condense, and produce a vacuum under the piston, without either an air pump, or condensing water; but the tables are now turned, and my triumph, over those who have illiberally assailed me, is complete. By the next packet, you may expect drawings, &c. of my engine; and, I hope, within one short year, to take a seat, with my friend, Dr. Jones, by the side of a generator, sustaining a pressure of 3000 lbs. to the square inch; for this pressure on the generator is required to produce a working power of 2000 lbs. to the square inch, upon the piston.

I have several times mentioned the name of our friend Lukens, who is here, and in pretty good

health. He has been introduced to many of the first characters, and is considered as very clever, particularly by one of the greatest philosophers, and best judges of the age. His fame is already high, and is rising, but it must of course require a residence here of some time, for him to be estimated, and remunerated, according to his merits.

This letter has been written, a few lines at a time, as I could catch a spare moment, and sometimes at intervals of several days. You likewise know, that the business of writing is one in which I do not profess to be at home; you will, therefore, I am sure, excuse any inaccuracy, or want of connexion, which it may exhibit, and believe me to be,

Yours, truly,
Jacob Perkins.

This extremely long epistle covers a great deal of ground and much of it is very obscure but of all the promises Perkins made in it, amid the jargon of scientific words, future events showed but very few were ever fulfilled. His mention of Sir Humphry Davy's *Zinc Protectors* for preventing corrosion in the cylinder of his engine, is intriguing. Davy had been for several years (in fact ever since 1823) conducting a series of experiments for the Navy Board to find some method of preventing the fouling and decay of the copper sheathing on warships and other vessels. His solution of this problem was to attach slabs of zinc to the hull by which means he hoped to discourage by galvanic action the marine growths that attached themselves to the ship's bottom, but this did not prove entirely successful. In a lecture before the Royal Society on January 22, 1824, Davy had stated that "he might describe other applications of the principle to the preservation of iron, steel, tin, brass and other metals." Just how Perkins applied this principle of zinc protectors to his engine is not known nor to what extent they were in any sense necessary. The copper alloy piston and the cast iron of the cylinder might have formed some galvanic action after a long period of rest, if the water used in the generator had been at all brinish.

Perkins' comments in his letter on McCurdy and the Hawkins patent for generating flash steam are enlightening as well as contradictory. As far as Perkins' patent of 1822 is concerned, in which he proposed to generate steam from highly heated water under compression, there was no similarity to Hawkins' method. But the pipe generator covered by his patent of 1827 was another matter. In this, water was preheated as before, but was afterward injected into a continuous set of tubes or retorts and the steam generated was expanded into a drum and so on into the engine. If we may consider the mechanical construction rather than the theory, the similarity of this to Hawkins' method seems fairly obvious.

Perkins dwells at some length upon Samuel Brown's gas vacuum engine, a potential rival to steam at that time. Brown's patents of 1823 and 1826 covered the use of his engine for both boats and road carriages, and each of these methods of transportation was successfully carried out by him. But the final conclusion of a committee of shareholders of the Canal Gas Engine Company, who were promoting Brown's patents, was that the consumption of gas (hydrogen) was too costly to enable their engines to compete successfully with the steam engine. Samuel Morey's gas engine in America was even less successful than Brown's. Morey's engine, mentioned by Perkins, was patented in 1826 and was demonstrated publicly in New York in 1829. This engine had two power cylinders about 4 inches in diameter and 12 inches in stroke. Turpentine vapor and air were drawn in through a small valve during a part of the upstroke of each piston and then fired by a spark from a small static electric machine. The burnt gas was exhausted through another valve during

the return stroke. There was no compression and the engine could never have developed much power.

Perhaps the most astounding statement made by Perkins in his letter is that on one occasion after raising steam in his generator to a pressure of 30 atmospheres, upon removing a plug from a hole previously drilled in the side, nothing issued from the aperture "all was perfectly quiet" and this at the time the engine was working from steam supplied from the same source!

That Perkins forwarded a copy of his 1827 patent to Dr. Jones is very probable but there it must have rested, for there is no record of it ever having been filed in the United States Patent Office.

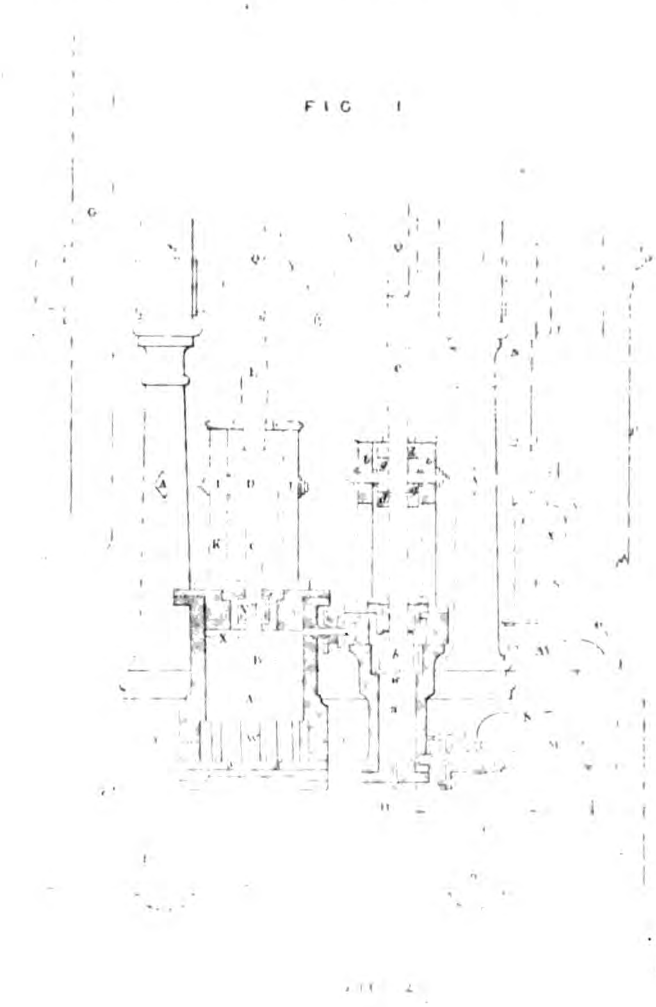
It is also very evident from Perkins' letter that he was still busily engaged in promoting the steam gun. The apathy of the British Ordnance Board in this direction had induced him to woo the French Government as a customer for his devastating weapon. At this time the French Minister to Great Britain was the Prince de Polignac, who had often attended the exhibitions of the steam gun in action at Regent's Park. The Prince had been greatly interested and had passed on his favorable impression of the gun to the Duc D'Angoulême, eldest son of Charles X of France. Thus it transpired that in 1827 a deputation of French notables, including several army engineers, headed by the Duc D'Angoulême, came over to England and a demonstration was given for them at the engineering works of John Penn at Greenwich.[168] But of this occasion and its sequel more will be said later.

It seems certain that Perkins, in addition to having his steam gun made and exhibited at Penn's Works, also had constructed there in 1827 the first compound uniflow engine, probably the only one ever built. Referring to Newton's *London Journal of Arts and Sciences* of October, 1827, it was stated: "Mr. P. having now erected at his new factory, near Regent Square, Gray's Inn Road, a very complete engine, having two single stroke cylinders, connected together, both worked with high pressure steam." This statement also gives the first intimation of a manufactory at Gray's Inn Road, which was taken over later by Perkins' son, Angier March Perkins, for his own business as a heating engineer. No further mention of these premises occur until Perkins' removal from Regent's Park in 1832. According to Perkins' letter to Dr. Jones it is indicated that Penn had several orders for these engines for steamboats at this time, to be constructed under special license from Perkins and Company. However, no mention nor trace can be found of the names of these vessels. It seems probable that while it was fully intended to carry out this marine application of his steam engine, the crises in Perkins' affairs, then already imminent, prevented their completion.

Perkins' promise to his friend Dr. Jones to take a seat beside him and a generator

[168] John Penn was born near Taunton in Somerset in 1770 and was apprenticed to a millwright at Bridgewater. He came to London in 1793 and after working as a foreman in several engineering shops, he commenced business for himself in 1801. His work was chiefly connected with flour mills and he was one of the first engineers (but with much opposition) to introduce self-acting machine tools. The first prison treadmill was constructed by Penn in 1817 for Brixton Gaol, to the design of William Cubbit of Ipswich. As the demand for steamboats increased the firm, under the name of John Penn and Sons, began building marine engines, particularly those with oscillating cylinders, later adapting them to screw propulsion about 1845. John Penn died in London on June 6, 1843. At this period, 1827, John Penn assisted by his son, William Penn, had not standardized their business, they were jobbing engineers who took any kind of work requiring skill and personal supervision.

Jacob Perkins' Compound Uniflow Steam Engine of 1827.



From a copy of the specification in the United States Patent Office.

The high pressure cylinder a and piston b, the throttle L and steam pipe N, leading into the admission valve M, operated by the cam T, through the mechanism OS, and adjusting screw x. The exhaust ports w communicate with the second cylinder A and piston B. The exhaust ports W lead to the condenser (not shown). X, the equilibrum valve, opened and closed by contact with the cylinder heads. The flywheel G and the two cranks YY, set at a slight angle to each other as drawn. Ee connecting rods and crossheads Dd, guided by the rollers Ii between the guide bars indicated by K. The metallic packing of the piston rods C is shown at V. The pump rod P is driven by the disc crank as shown. H is a loaded valve to relieve trapped water in cylinder a. At fig. 2 is shown the method of making the exhaust ports so that the rings are retained normally in position to the end of the piston stroke. The action of the engine is described in the text.

sustaining a steam pressure of 3000 pounds evidently refers to one of these projected steam vessels which was to cross the Atlantic with a safety and power hitherto unknown. It was with such promises that Perkins kept alive the public interest, but seems to have failed to offer in the end any concrete results. This feeling was expressed in one of the popular publications of that day with a rugged candor which did not mince words: [169]

> The authorized statements which have been published from time to time respecting his discoveries have been, in a culpable degree, various, loose and contradictory. Of *vapour*, too, there has always been more than enough. Mr. Perkins would, probably, do a service to himself, by giving frank and plain answers to the following questions:
>
> 1—Is the engine which he now offers to the public the same in its master principle with that which he brought forward in 1824.
>
> 2—What is the actual saving obtained by his present engine as proved by trial and experiment.

Harsh opinions, perhaps, but could it not be truly said that Perkins was in a sense to blame by reason of his own equivocal attitude?

There is on record at least one authentic demonstration of the capabilities of Perkins' uniflow engine which was at the time much publicized with considerable testimony as to the engine's power and economy of operation. This particular engine was erected at the excavations of St. Catherine's Dock (see Map 6) which was then being constructed on the Thames just east of the Tower of London.[170] This ambitious project was commenced May 3, 1827 and completed on October 25, 1828. As the digging progressed, the tide water and springs constantly filled up the work and two large Boulton and Watt pumping engines were installed to drain back the water into the river.

The difficulty of eliminating the water sufficiently for the workmen to carry on the excavating continuously probably influenced the architect Philip Hardwick, who was also the superintending engineer, to welcome any such assistance in pumping as might be offered by inventors of new types of steam engines who were anxious to try out the capabilities of their machines. Besides Perkins, among those who offered their services was Dr. Alban with his fused metal generator which has been previously mentioned. This supplied power for a small pump and the boiler made plenty of steam, but proved to be a tricky proposition in action, as the expansion and contraction of the metallic medium often broke the containing boxes and allowed the fused metal to escape into the furnace.

Perkins' pumping engine at St. Catherine's Dock was erected in the summer of 1827

---

[169] *Mechanic's Magazine* vol. 8, November 17, 1827. This publication was one of the earliest of the weekly magazines devoted to the requirements and interests of the practical mechanic. Also it was one of the first to publish a full account of Perkins' steam engine experiments (Vol. 3 September 13, 1823). The editors also gave much space to correspondence dealing with the various aspects of Perkins' generator and the principles involved. But by 1827 the attitude of the *Mechanic's Magazine* had become decidedly hostile to Perkins' further experiments.

[170] St. Catherine Dock, named for the church of St. Catherine by the Tower which had to be removed before the excavations for the dock could be started. Since 1829 this name is always spelled with a K. The works were designed by Thomas Telford, 1757-1834, and they involved the removal of 1,250 houses and tenements. The extent of the docks and warehouses comprise twenty-three acres, eleven of which are water and 120 ships of various tonnage could be accommodated at one time. At the entrance was a lock 23 feet wide crossed by a swing bridge and a 200 h.p. steam engine was required to fill and empty the lock. During the excavations the tide on one occasion burst through the retaining dam and flooded eight acres of the ground to a depth of thirty feet. It is said that a vast number of cats were kept in the warehouses to destroy rats, being maintained at a cost of £100 per year.

and was a single cylinder uniflow rated by Perkins himself as about thirty horsepower. The engine was connected to the pumps by gearing. From the *London Journal of Arts and Sciences*, 1827, was extracted the following account of it, with a testimonial signed by three of the contractors' engineers:

We have the pleasure of announcing, that Mr. Perkins has at length, in a very satisfactory manner, proved the superiority of his newly constructed high pressure steam engine, by working it against two other steam engines, upon the low pressure principle.

This small engine, which we have several times mentioned in our present volume, has been, within these few days, set up at St. Catherine's Dock, and employed in pumping water from the excavation. There have been four steam engines engaged in the prosecution of these works; two for excavation, and two for pumping out the water. Mr. Perkins's engine stands along side a low pressure engine, of sixteen horse power, which is determined by the area of its piston.

The diameter of the piston, that is, the bore of the steam cylinder of the new high pressure safety engine, is eight inches, and its stroke twenty inches. It was connected, by gear, to a beam that made sixteen vibrations per minute, and raised two alternating pump buckets, the diameters of which are fourteen inches, and their strokes three feet three inches.

We were extremely anxious to communicate our observations on the effect and action of this engine, but the first time of its working can hardly be considered to be a fair criterion of its capability. We understand that it is expected to perform twenty strokes per minute, and will then, it is said, lift 900 gallons of water every minute. Our limits will not allow us to say more upon this subject at present, but we intend to take a more deliberate view of the engine in a few days, when it gets fully into action. We think it important, however, to subjoin the following certificates, which speak for themselves, and require no comment from us.

"We, the undersigned, certify, that there are two low pressure steam engines, employed night and day in discharging the water which flows into St. Catherine's Dock, from the land-springs, &c.; that one of them is a sixteen, and the other a ten horse engine. We also certify, that Mr. Perkins has recently put up a small high pressure steam engine, the diameter of whose piston is eight inches, its stroke twenty inches; and that we have seen this engine pump the same quantity of water from the Docks which has been heretofore pumped by the other two."

James Lamon,
Pearson Woodward,
Thomas Browne.

Another account by Thomas Gill, a consulting engineer and who was also editor of *The Technical Repository*, tells of the engine's performance at a time when the two Boulton and Watt engines were under repair and Perkins' engine handled the pumping alone day and night for nearly five consecutive days.

The Editor was highly gratified on Wednesday, the 10th ult., (July) by witnessing the performance of this engine at the St. Catherine's Docks, where, as Mr. Hornblower, (a nephew of the celebrated Mr. Hornblower,) the intelligent engineer and superintendent of it, informed him, it had been incessantly at work, night and day, from 12 o'clock on the Friday night preceding, and had, alone, kept the excavations free from water, although the river had once made an entrance to a very considerable extent.

At the time the Editor saw it, it was working two pumps; but, owing to its having got the water so completely under, it was then drawing air mixed with the water.

Mr. Hornblower stated, that it was then working at a pressure of about 270 lbs. upon the square inch, it not being one-third of its full power; and that it only consumed at the rate of one bushel of coals per hour; but that it ordinarily did the work of a 12-horse engine.

Its motion was exceedingly rapid, and indeed it was necessary to abate its velocity by the introduction of a pinion, fixed upon its main-shaft, working into a larger toothed wheel upon the crank-

shaft which actuated the pumps; and, owing to its working with so great a velocity, one of the great advantages of working high-pressure steam, the engine itself is of a very light construction, not requiring such massive shafts, &c., to be employed, as in the ordinary cases of the low-pressure steam-engines.

Mr. Hornblower stated, that another engine employed to drain the excavations, consumed two and a half bushels of coals per hour.

This testimony by Thomas Gill, who could in every way be considered reliable in reporting what he saw, certainly vindicated the reliability of Perkins' generator and engine. Yet, in spite of this public demonstration, there was something lacking to make the invention a real success. Without question Perkins' machinery was constructed in the best possible manner by the most skillful workmen of that day and no one can gainsay the fact that Perkins himself was a competent mechanic with long years of experience in the arts and crafts of his times. Thus the practical work performed at St. Catherine's Dock should have done much to further the general adoption of this type of prime mover provided all had been well in other respects. Yet shortly after this Perkins withdrew his engine and generator from the dock and at the time maintained a discreet silence as to the reasons actuating this move, though he must have been well aware that while his engine made a spectacular showing, there were very real faults which were not apparent to the onlooker. Nearly ten years afterwards, at a meeting of the Institution of Civil Engineers in 1836, Perkins read a paper on *The Causes of the Difference of Duty by the Cornish and Soho Engines, and on the Improvements of Steam Boilers*. In the course of his remarks, he then said:

I should mention that at the time these experiments were made at Saint Katherine's Dock, I had not overcome all my practical difficulties, for the generators would fur up and then burn out. I, however, had no reason to despair, for although the cost of wear and tear of the generator was greater than the common boilers, yet the saving otherwise was far greater.

Here, then, was at least one of the principal reasons why Perkins did not continue his demonstration at the dock and also why he could not offer with confidence his high pressure engine to industry, where reliability was far more essential than any economy in fuel.

That Perkins realized the inherent deficiencies of square section tubes of cast iron is apparent, for in a communication to Dr. Jones in 1829 he described an improved form of element that was "round instead of square with cast radiating ribs proceeding from the interior surface of each tube all around to the center of it where they terminate in thin edges. Two of these were tested in the hottest part of the furnace and were found never to get red hot and also to generate steam more rapidly." Perkins also described another kind of tube he had invented. It was of circular form on the upper side, with a deep groove on the under part, forming a water passage like an inverted U. This type of heating element was the principal feature of the flash steam generators developed by Leon Serpollet during the early 1890's for use in the public service vehicles of the Compagnie des Tramways de Paris, and the arrangement of the tubes follows very closely those used by Perkins in his boiler of 1827. The saving on coal[171] during the time Perkins' engine was at work

[171] In the *Franklin Journal* of 1829, p. 287, an account is given of Perkins' compressed fuel or briquettes which reads: "The smallest parts of gas coke well sifted were used in the furnace. The dust is mixed with 1/30 part clay and water and compressed in a tube and after drying on top of the furnace, they can be used for fuel. Mr. P. claims that his engine can be maintained in motion by this fuel for twelve hours at a cost of 11½ pence."

appeared to be advantageous, but his methods for accurately measuring the horsepower, while impressive to the lay mind, failed to satisfy the more methodical reasoning of engineers. In the *Register of Arts and Sciences* of 1827 is an account of a brake test on the single cylinder uniflow engine by Perkins at his own works. It was performed by a lever made to press on the periphery of the flywheel, one end of this lever was eight times as long from the point of contact on the rim of the flywheel as it was from the rim to the fulcrum. On the long end of this lever was hung a weight of 300 pounds, and after allowing something for loss by friction, by contact with the rim of the wheel (this was 25 feet in circumference), Perkins stated that in one hour with the consumption of 42 pounds of coal the equivalent of 72,000,000 foot pounds was raised.[172] The saving of coal was estimated at about one-third over that used by a Boulton and Watt rotative engine of similar power.

The reaction in America to Perkins' sensational experiments in London was not great even in his native town of Newburyport. That Perkins had kept his brother Abraham well informed as to the progress of his invention is borne out by the following brief notice in *Poulson's American Daily Advertiser* of April 26, 1827:

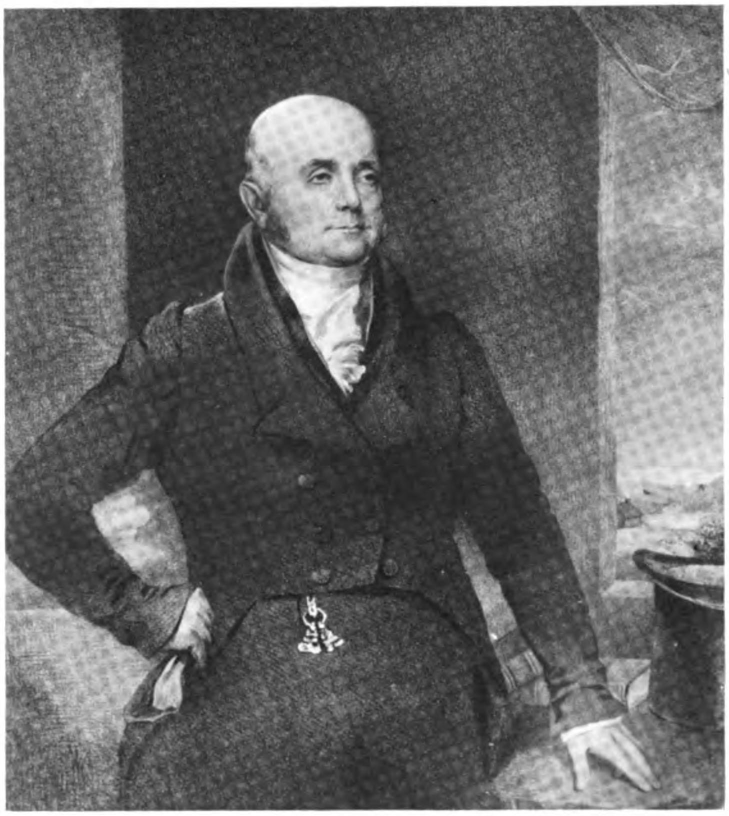
> Perkins's Steam Engine—A correspondent of the Newburyport Herald says:—"With respect to Mr. Perkins's Steam Engine, I would observe, that letters have lately been received in this town from London, which give the most flattering assurances of the ultimate success of Mr. Perkins's improvement. From a hasty description given of the mechanism of this great work little doubt can be reasonably entertained by any who are acquainted with the general principles of the steam engine, but that Mr. Perkins will soon pass the high pressure rubicon and realize a triumph in the age of splendid discoveries.

Also from the same paper, dated June 21st of the same year, is found a notice of Dr. Jones' special lecture on the high pressure engine, evidently inspired by the voluminous letter which he had recently received from London.

> LAST LECTURE ON THE STEAM ENGINE.
>
> Franklin Institute.
>
> This Evening, (Thursday, June 21st.) at 8 o'clock, Dr. Jones will deliver a Lecture on the Steam Engine.
>
> The particular description given in his former Lectures will be omitted, for the purpose of more fully explaining some points which have been but briefly treated by him; the high pressure engine, its application on rail road, &c. and the recent information from Mr. Perkins on elastic steam, will be particularly noticed. Tickets, &c. as before.

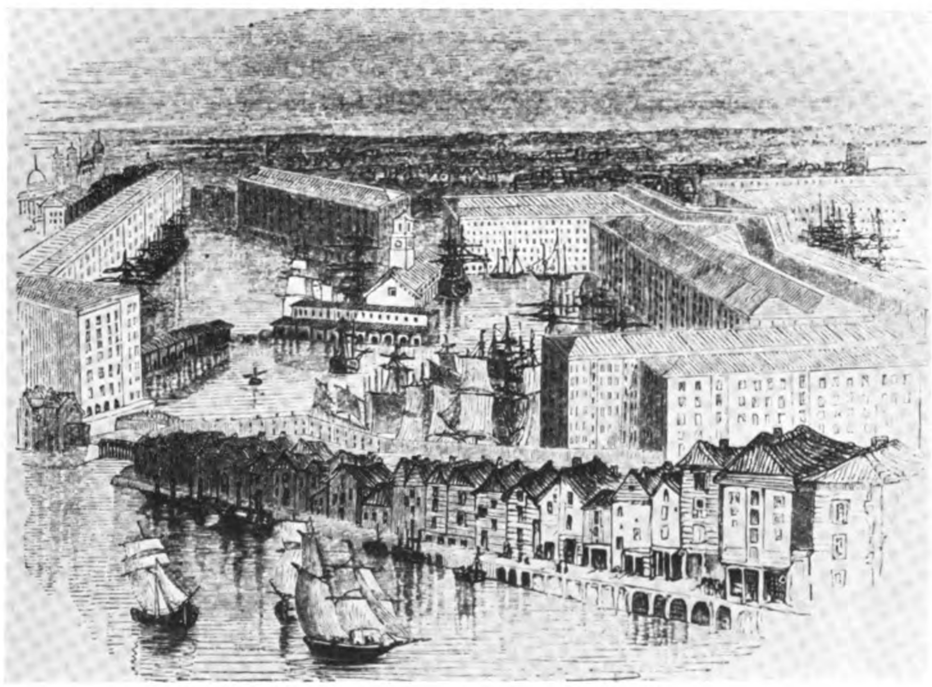
If Perkins had been willing to submit one of his engines to a body of representative engineers for a valid and disinterested test, he would have been in a far stronger position

[172] For estimating the power of his engine, Perkins simply applied a long lever of the second order to exert friction upon the flywheel, a somewhat crude variation of Baron de Prony's friction dynamometer, invented by him in 1821. This device is more generally known as Prony's brake or friction band and encircles the entire surface of the flywheel rim. By an attached lever arm and a pan for adding weights, the actual horsepower given out at the shaft of the engine can be determined and this is called the brake horse power. In this test of power the fuel consumption is not a necessary consideration. In estimating the power of pumping engines, the term "foot pounds" is used, which is the number of pounds that can be raised one foot high by the consumption of a bushel of coal in an hour. In Cornwall this is called the duty of an engine. The best duty performed by a Cornish engine in 1827 was 67,000,000 foot pounds by Woolf's 90 inch cylinder engine at the Consolidated Mines.



Jacob Perkins at the height of his Steam Engine Fame.

From a lithograph on stone by Richard J. Lane, published by the American Library of London in 1825. *Reproduced by courtesy of* Miss Margaret W. Cushing, Newburyport.



St. Catherine's Docks, About 1840.
Engraved by Henry Sears for Charles Knight's *London.*

even if his theories had not proved so efficient as he expected. But even more to the point, is the question of the ability of his machine to have stood up under continuous work. In this regard, the authors have failed to find any instance in which a Perkins engine had been in continuous operation for at least a month under independent ownership or management. Perhaps the answer to this can be better understood by quoting from the *Mechanic's Magazine* of September 20, 1828, which said:

> Of the actual power of this engine, nothing is accurately known. The subtile nature of the steam used seems to be the principal cause that prevents it general introduction, it being impossible for the utmost nicety of workmanship to prevent its escape. The extreme violence of its action is also a great drawback. In the engine that was employed at St. Catharine's Docks, the steam *ran through her;* and, indeed, the action was so violent as to loosen and break the screws.

The latter part of 1828 witnessed a further sad confusion in Jacob Perkins' affairs. The mobile steam cannon, which had been ordered by the French Government, was a comparative failure. The weapon had been constructed in the best possible manner at the Greenwich Works of John Penn early in the year and had its preliminary trials about March. A correspondent to the *New Monthly Magazine,* who was an eyewitness of these trials, said that "Mr. Perkins' 4 pounder had its trial a few days ago near Blackheath. The length of the barrel is about 6 feet and the diameter of the bore which is grooved as a rifle to carry a ball of about 3 inches." The test was made probably on the historic ground of Whitefield's Mount, as this spot had long been used as a butt for artillery practice. John Evelyn, in his diary under date of March 16, 1687, writes: "I saw a trial of those devilish, murdering mischief-doing engines called bombs, shot out of a mortar-piece on Blackheath. The distance that they are cast, the destruction they make where they fall, is prodigious." So history was again repeated in March of 1828. The eyewitness goes on to describe the actual conditions attendant on the shooting of Perkins' gun: "the ground on which the firing took place at Greenwich only admitted of two hundred yards distance and lead shot were made use of for the experiments, though, for the purpose of economy, Mr. Perkins recommends iron shot covered with lead about a quarter of an inch in thickness so as to accommodate itself to the rifle. Steam was raised to 700 pounds to the inch and the piece was loaded with ball, and discharged at the astonishing rate of twenty-eight or thirty times a minute. The loading is effected by dropping a ball into a cavity over the breech of the gun, which aperture is closed by a spring or slide, traversing in a horizontal direction between the steam and the barrel."

This formidable piece of steam operated artillery, upon which Perkins had placed such high hopes, was probably sent over to France in October for its military trials, but Perkins was unable to attend these, owing to illness, though optimistically he had anticipated a complete success for his weapon and therefore much further patronage from the French Government. Before Perkins was aware of the unsatisfactory outcome of the tests which were held at the Castle of Vincennes, just outside Paris, he opened negotiations with his own Government by seeking an interview with James Barbour,[173] the American Minister.

[173] James Barbour, lawyer and statesman, born in Virginia on June 10, 1775, and died there in 1842. In 1815 he was appointed to the Senate and in 1825 President John Quincy Adams made him Secretary of War. In 1828 he was sent to England as American Minister but on the election of President Andrew Jackson in the following year, he was recalled.

The time seemed especially propitious to Perkins as Commodore Charles Morris[174] was then on a tour of the British and French dockyards and had expressed more than passing interest in the steam gun. Barbour was apparently out when Perkins first called on him as the following letter indicated: [175]

No. 4 Harpur Street,
Theobald's Road, London Decr. 5 1828

To His Excellency
Barbour Esq.
Dear Sir:

I called at your dwelling yesterday not only to pay my respects but to redeem a pledge given to R. Rush, Esq. and Commodore Morris, to wit, that when my Steam Artillery should assume any tangible shape I would inform my Government of the fact through its Ambassador.

I will now merely state that a Committee which was appointed by the French Government to examine into its merits, after much investigation, and long experiment have recommended its adoption.

The rest which I have to communicate and which is of a very important nature, I will reserve for your private ear.

I will thank you if agreable to appoint an early hour when I shall be happy to see you on the subject.

I have the honor to be
Your Excellency's
Most obedient humble servant,
Jacob Perkins.

It will be noted that this letter, written by Perkins, was sent from No. 4 Harpur Street, which was the business address of Angier March Perkins, who had that year left Fleet Street to start his own career as a heating and steam engineer.

Exactly what happened at the Vincennes trials is no doubt on record in the French Military Archives, but these facts are not available to the authors and the following inadequate but significant account taken from *Niles Weekly Register* of January 3, 1829, will have to suffice:

It appears from recent experiments, that the ingenious invention of our countryman, Perkins, has not answered the expectations formed of it: the steam gun sold to the French Government, after what is considered a fair trial, does not possess the power of throwing a ball more than half the distance that a common cannon of the same caliber did; however, if it could be improved in power, it would, no doubt, become a powerful engine of war.

This brief but nevertheless graphic account of the superiority of gunpowder over high pressure steam needs some consideration. Based on the showing made by the steam gun which propelled small bullets with a velocity which more than surpassed gunpowder, Perkins could but assume that an equal effort could be relied upon with shot of any size.

[174] Charles Morris, born in Woodstock, Connecticut, July 26, 1784. He entered the navy as a midshipman in 1799 and was promoted captain in 1813. From 1823 to 1827 he was Navy Commissioner, as such he had a vote upon every important question of naval administration. From 1851 until his death in 1856 he was chief of the Board of Ordnance. Richard Rush, 1780-1859, mentioned in connection with Captain Morris, was the son of Dr. Benjamin Rush of Philadelphia. Richard Rush was minister to England from 1818 until 1825 when he returned to America. In 1829 he was again in Europe negotiating a loan from Holland for the corporation of Washington and other cities.

[175] Manuscript Room, of the New York Public Library.

But the expansion of steam did not prove nearly as effective as the expansion of gunpowder, therefore if the lead balls, which were 2.60 of an inch in diameter and weighed about three pounds, did not exactly fit the barrel, the expanding steam would rush past the ball without giving to it the equivalent velocity. With gunpowder, the expansion is so rapid that it amounts to a blow and would impart its force to the ball irrespective of the loss of part of the gas which might pass between it and the bore of the gun. The leaden balls used were made in metal molds but even so could not be considered truly round without some kind of machining after casting to render them all a perfect spherical fit. It must also be supposed that the French artillerymen would have been heavily prejudiced in favor of gunpowder and selected with more than ordinary care their cannon with which to compete at these trials.

Apart from these speculations, a comparison of the two forces involved will supply the true answer. Considering gunpowder as manufactured in that day, it was proved that when closely confined, as in a cannon, it produced a pressure of 6½ tons per square inch,[176] equal to 14,560 pounds. Perkins said at the time of the first public steam gun trials in 1825 that he employed a pressure of about 900 pounds of steam to the square inch, also he repeatedly stated that "a pressure might be carried even to 200 atmospheres with perfect safety," but this, which equals 2,800 pounds, still falls far short of the initial pressures obtained from gunpowder. From this, it must be fairly obvious why Perkins' steam artillery failed lamentably to live up to its earlier promise where the velocity imparted to a small ball was mistaken for unlimited propelling power.

The American Government, in view of the unsatisfactory showing of the steam cannon in France, did not pursue the matter further. It is also most unlikely that Perkins ever received any recompense for his work from the French Government, although they had agreed to pay him 25,000 francs for his weapon. The political situation in France was by then working up to a climax and revolution was already in the air. Prince de Polignac, who was Minister of Foreign Affairs and Premier in 1829, was the only man to whom Perkins might have looked for payment, but de Polignac in 1830 was imprisoned and later forced into exile.

There is no indication that Perkins' manufactory at Regent's Park or the newer premises near Gray's Inn Road were provided with the necessary machine tools capable of making his steam engines and generators. Such details, already recorded, as flywheels of 25 feet in circumference, cylinders of 9 inches diameter and other component parts require very heavy lathes and other machinery to aid in their finishing. All engineering establishments of that day did their own iron and brass casting, as well as the turning, shaping and fitting together of the parts. But no contemporary writer, not even Perkins, mentions at any time that this sort of work was undertaken, even at the Water Lane premises.

Everything seemed to point to the obvious conclusion that all the necessary work was farmed out or wholly made by some recognized engineering firm to Perkins' special order. From the few references to be found on this aspect of Perkins' steam engines, it is evident that his manufactory was a place given up to experimental work and demonstrations only. An advertisement, one of several to be found in the technical magazines of this period, rather bears out this belief:

[176] *A Million of Facts and Correct Data*, by Sir Richard Phillips, London, 1832.

The High Pressure Safety Steam Engine.—Perkins and Co are now ready to receive orders for steam engines. They will guarantee the saving of, at least, one half of the fuel, three-fourths of the weight, and three-fourths of the bulk, and will charge but two-thirds the price of the best, London made, condensing engines; reserving the right to one-third of the savings. Orders and communications left at Perkins and Heath's, No. 69, Fleet-street, will be attended to.

The Fleet Street premises were almost always used by Perkins in matters of business, as apparently the clerical work attendant on his inventions was done from this address, and hardly ever from his manufactory. In May of 1829 Joshua Butters Bacon assumed the place of Heath as partner in the engraving business and the firm then became Perkins and Bacon, which dates this form of advertisement as about 1827-1828.

At this time, 1829, Perkins seems to have been very seriously embarrassed financially and he was unable to carry on with his experiments. It is stated by him that his monetary partner in the engine business was responsible for his difficulties. Perkins was always most reticent as to who this person was and the most careful search has failed to reveal the entire facts or even the exact date of the trouble. Perkins, at a meeting of the Institution of Civil Engineers in 1836, was asked why he did not go on with his high pressure engines, to which he replied:

Often I have been asked why I did not follow up my patent if I was satisfied that there was no fallacy in the result of my experiments. My answer has been that very soon after those experiments my monied partner failed and died and his creditors put the patent in Chancery where it now remains, and I have been obliged to turn my attention to other means of earning a living.

Again later in a communication to the *Franklin Journal* in 1837, answering Dr. Jones' probing as to the future of his steam engine patent, Perkins said:

The particular causes of this delay are too much of a private nature to justify or warrant their detail, and I will simply state therefore that the extravagant demands made upon me in consequence of the insolvency of persons with whom I have been connected involved me in law and that the seal of Chancery was placed even upon my unfinished experiments.

It would seem from all this that Perkins had pledged his steam engine patents against some equivalent financial aid, and at the unexpected death of his associate they were held as assets of the deceased's estate. But for the fact that Perkins stated his "monied partner" died, some relation could be drawn with those supporters of his steam engine experiments, who have already been mentioned, such as Dyer, Wright, Lukens,[177] and Dr. Church, but all of these men were alive long after 1829. That Perkins always remained silent on this subject was of course his own affair, but a careful check up on the four associates of Perkins of this period, 1827, reveals that the person referred to as Mr. Wright of New York was Isaac Wright, who in partnership with Francis Thompson and his brother Jeremiah

[177] Isaiah Lukens was a clockmaker by trade and was born at Horsham, Pennsylvania in 1797. He was elected a member of the American Philosophical Society in 1820 and from 1824 to 1825 he was vice-president of the Franklin Institute. In 1826 he visited France and England, returning to Philadelphia in 1828 and resumed his business as a clockmaker. Lukens was responsible for the beautiful clock in the State House, in the Bank of the United States and in the Philadelphia Bank Building and for many other fine clocks in the city. In 1829 he was again elected vice-president of the Franklin Institute and continued in this office until his death on November 12, 1846. A striking portrait of Isaiah Lukens now hangs in the Secretary's room at the Franklin Institute, a companion picture to one of Jacob Perkins which is given in the front of this work.

Thompson, founded the Black Ball Line of sailing packets in 1817. These ships traded between New York and Liverpool, carrying cotton to England and returning with cargoes of woven goods. Jeremiah Thompson was one of the heaviest importers of British cloth of his time and he was also a progressive shipowner who built one vessel after another, each superior to the last. His speculations finally brought him to financial ruin in 1827 and in 1828 he died a discouraged and broken man. Perhaps here is the answer to the question of Perkins' financial backer, for what is more probable than Jeremiah Thompson becoming interested in the steam engine which would have enabled him to compete on such advantageous terms with his sailing ship rivals?

Perkins, believing that in his high pressure steam engine lay the future of marine transport, again turned his attention to some better means of propulsion other than side paddle wheels, which were exclusively used on all vessels of that day. His previous invention of double paddle wheels, revolving in opposite directions, had not proved upon trial very successful, owing to the inherent weakness of the long thin blades. Also their arrangement could not be readily adapted to the existing types of engines and, moreover, any form of stern propulsion was not looked upon with favor by the shipbuilders of that day. In Perkins' second patent for a "screw propeller," dated July 2, 1829, it is doubtful if he had made any great advance toward greater efficiency, although Perkins himself thought so well of his idea that he patented it also in the United States on November 30th of the same year. By referring to Plate XXXII from the American patent, it will be noted that the wheel shafts AA were set at an angle of 45 degrees to the center line of the hull and the float boards of the wheel were also set to this angle, in relation to its shaft. This arrangement enabled each float to exert its maximum thrust in a perfectly flat direction momentarily when at its deepest immersion. At B is shown one of these wheels used as a stern propeller and arising from this application there occurred a very interesting controversy between Isaac Doolittle,[178] who at this period was traveling agent for the Bennington Iron Furnace of Vermont, and Dr. Jones, through the medium of the *Franklin Journal*. This piece of

[178] Although Isaac Doolittle does not loom very largely in Perkins' affairs, he requires more than passing notice. Doolittle was born in New Haven, Connecticut, on October 13, 1784. He spent eleven years of his life in France and his complete mastery of the French language made him invaluable to the United States Consulate in Paris where he performed the duties of chancellor or secretary. In his spare time he studied mathematics and physics at the Polytechnic and at the University of Paris. Doolittle and William Armand Barnet, son of Isaac Cox Barnet the American Consul, attempted in 1818 to secure an American patent for an improvement in steamboats. An ardent admirer of Oliver Evans, Doolittle had long projected the translation into French of the work of Evans on the steam engine. In 1819 the French naval officer, Capt. Marguery, obtained a copy of the *Abortion of the Young Steam Engineer's Guide* while cruising in American waters and gave it to Doolittle who was then enabled to publish this work by Evans in the French language, under the title *Manuel de l'Ingénieur Mécanicien Constructeur de Machines A' Vapeur*, at Paris in 1821. Returning to America in 1822 with William A. Barnet, they in partnership commenced a lithography business at No. 23 Lombard Street, New York, which was the first of its kind in America. This venture lasted barely a year and by the end of 1822 Doolittle had joined with Seth Hunt and J. D. Quimby in the management of the Bennington Furnace in Vermont which had been in existence since 1806. Under a change of ownership in 1823 the Furnace became the Bennington Iron Company and Doolittle was made agent for the proprietors and in this capacity he traveled extensively throughout the New England states. About 1846 Doolittle moved with his family to Rochester, New York, and there became proprietor and agent for Crossett's Patent Stave machine. Doolittle died in Rochester on April 17, 1852. In 1827 Doolittle had obtained a patent for an ingenious method of feeding boilers automatically. This was described in detail in Dr. Benjamin Silliman's *American Journal of Science and Arts* of that year. Doolittle was a continuous correspondent of this publication and it was through this medium that he became acquainted with Perkins' work with the steam engine.

correspondence, with Jacob Perkins' invention as the storm center, appeared in 1831 and it opened with a letter from Doolittle, which read:

Some three or four days after I received the June number (No. 6, vol. v.) of the Journal of the Franklin Institute, I left Bennington on an excursion to the west. On Saturday evening, 10th July, being at Syracuse, I saw a steam boat arrive, on the canal, from the west. Some gentlemen present, who had already seen that boat, observed that her machinery was of an unusual construction. I immediately went to the quay, and in the few minutes the boat remained, got into conversation with the person whom I was led to believe was the inventor; he invited me on board to examine the machinery. I had only time to see the wheels, and you may judge of my surprise when I found that, in the inclination of the buckets, and in the angle which the axes of the wheels formed with the plane of the keel, they were exact *fac similes*, or rather, perhaps, exact prototypes (for they were probably made first) of the wheels invented by Mr. Jacob Perkins, and described in the above number of the Journal. The gentleman above alluded to informed me that the specification for these wheels had been sent to Washington in November, 1828, and a patent obtained in November, 1829.

On my return home, I sought in vain among the notices of patents, for some indications which should, at least, lead to the discovery of the name of the author or inventor, and it was not until yesterday, that I learned, by a letter from a friend at Syracuse, that it is Mr. Benjamin M. Smith, of Rochester, Monroe county, New York. On recurring to the Journal, with these data before me, I find at page 136, vol. v. that Mr. Benjamin M. Smith did obtain a patent on the 20th of November, 1829, (ten days prior to the date of Mr. Perkins' patent.) There is nothing, however, in the editor's notice of Smith's patent which can induce the belief that he thinks the invention entitled to the least consideration, or respect; on the contrary, he says, "wheels of the above kind have been patented, tried, and abandoned, long since," while, in speaking of an exactly similar contrivance by Mr. Perkins, he says, page 385, same volume, "should the advantage produced by the present paddle wheel be, in its amount, but one-half equal to the ingenuity manifested in its construction, we think it will be the best, by far, which has yet been proposed."

I have not the honour of a personal acquaintance with Mr. Perkins, though I have long known him by reputation, and feel a high respect for his mechanical talents. Of Mr. Smith I have never heard until now; but, it seems to me that, if an invention is to be judged of by the intrinsic merits, either of its ingenuity or its usefulness, the same thing which in one case could call forth such unqualified encomiums, ought, in another, to command, at least, a small share of courtesy, even though its production should not be accompanied by a name already resplendent with distinguished honours.

As I am unwilling to suspect Dr. Jones of either intentional injustice or undue partiality, I must suppose that either the drawings or the specification, or perhaps both, were so defective that he could not derive from them a correct understanding of Mr. Smith's invention. But, however this may be, I beg leave to repeat that the two inventions, (though no doubt both *original*) are exactly similar in every respect. The boat I saw is called the "Novelty," and her wheels are fixed in the stern.

I beg you will attribute this intrusion to its true motive—my love of truth and justice.

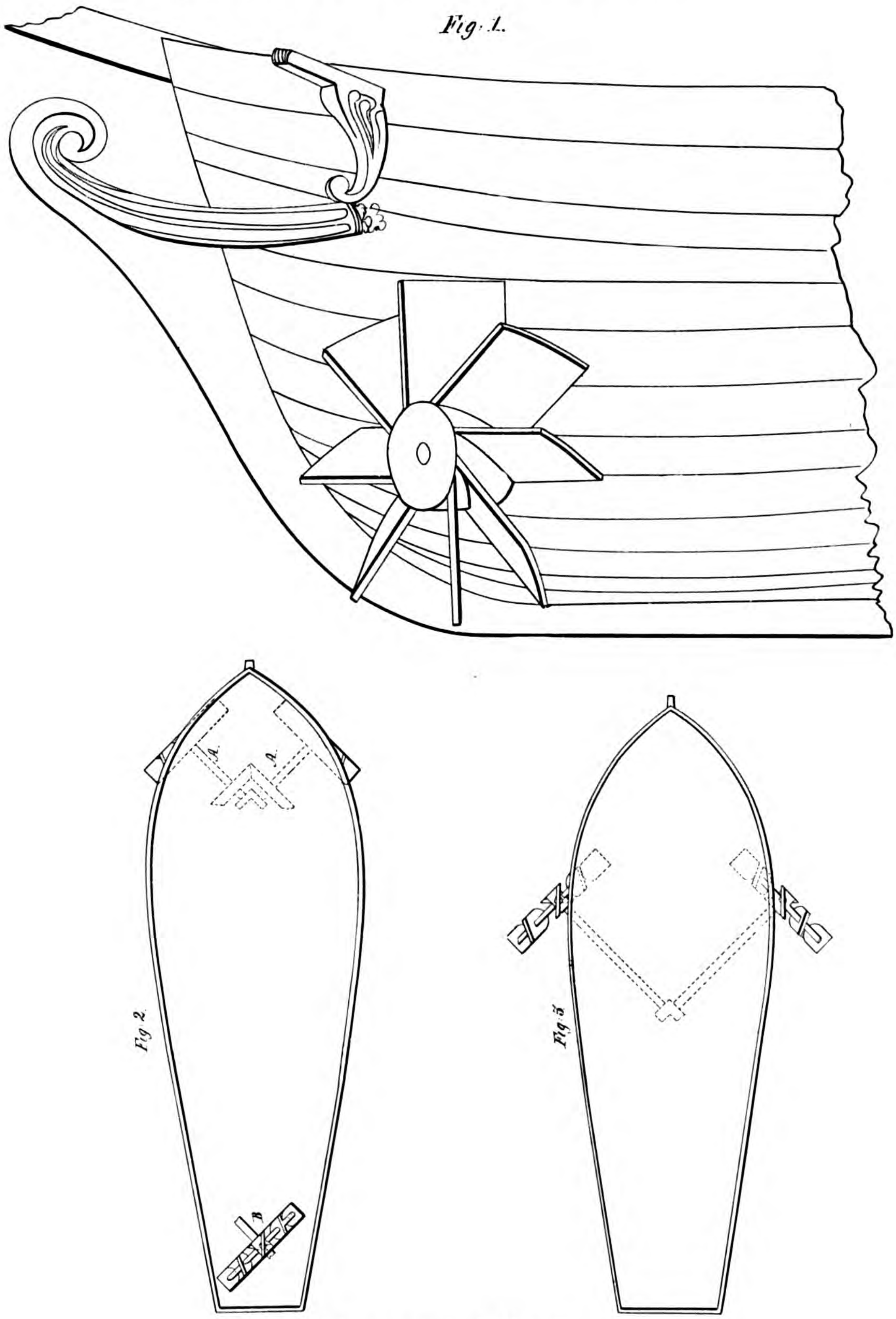
I am, sir, very respectfully, your obedient servant,

I. Doolittle.

To this letter, Dr. Jones replied with much asperity, defending his friend Perkins and the patent, and claiming that the Perkins and Smith wheels were on an entirely different principle:

Remarks by the Editor.—Although the above letter is dated in August last, it has but just come into the hands of the Editor, or it would have received an earlier notice. We have not the temperament which will admit of our sitting at ease under the grave charge of partiality, from an intelligent correspondent, who is actuated only, as we really believe, by the "love of truth and justice;" we are prompt either to correct our mistakes, or to repel an unworthy insinuation, or a false charge. Whether the animadversions made in this Journal, have been tinctured with partiality, let some of our friends tell,

Jacob Perkins' Screw Propelling Wheels for Steamboats.



Reproduced from a copy in the United States Patent Office.

Fig. 1.—The propelling wheel on the port bow. Fig. 2.—Plan of the bow wheels and the stern wheel B. Fig. 3.—The propelling wheels placed more amidship.

whose inventions have passed under review; and whether such has been the fact in the case before us, will soon appear.

We are far from Syracuse, and far from the boat which Mr. Smith had put into actual operation, but we have the testimony of Mr. Doolittle, and the patents of Mr. Perkins and of Mr. Smith before us, and will place them before our readers, when it will plainly appear that either Mr. Doolittle saw "what is not to be seen" in the angles of the buckets and shafts of Mr. Smith's wheel, or the latter gentleman, finding that his *"smoke jack"* wheel must take its place among those which had "been patented, tried, and abandoned," had determined to essay that, upon the *ingenuity* of which we had passed "unqualified encomiums." We believe the latter to be the case. That our readers may see the grounds of our belief, we now give his specification, and a cut from the drawing which accompanies it.

Benjamin M. Smith, of Rochester, New York, describes his *smoke jack* wheel as a "new mode of sculling wheels or screw propelling wheels" and his patent is dated November 20, 1829. Perkins' patent paddle wheels were never put to any practical use on any vessel. The angular shafts required bevel gearing to connect up with the engine just as in the earlier patent of 1824. This arrangement added to the expense of building and did not fit well into the limited space which could be allotted for the essential propelling machinery. It is hard to believe that Perkins himself would have placed much faith in these angular paddles if he had made any preliminary trials in the open sea. Most especially does this apply to the stern wheel shown in the specification drawing at B fig. 2. In an account published in the *Franklin Journal* of 1830, Perkins states that he made a comparison of his angular paddle wheel with one of ordinary design in a tank of water 36 feet in circumference. Two small model boats were prepared with wheels of equal dimensions and were revolved by a cord and falling weights. He found that his improved wheel was superior two to one over the old style due to its lifting less back water. The American patent was eventually acquired by Joseph Hall, a merchant shipper of Boston, but nothing is recorded regarding the use which he made of it.

Perkins was now close to sixty-four years of age and he must by this time have realized that his work during the past ten years had not fulfilled his expectations. Financial difficulties probably worried Perkins far less than the fact that he had been unable to carry on his sensational experiments with high pressure steam and thereby fulfill, at least in part, some of the promises made to his numerous friends. Perhaps hurt pride and pressing debts may have damped Perkins' buoyant enthusiasm to some extent but nothing seemed to impair his boundless ability for planning and inventing. With the abortive ending of the steam gun trials came a more tranquil way of life for Perkins, for it was about this time in 1831 that he and Mrs. Perkins and their daughters left Fleet Street to live in the commodious home of his son, Angier March, at 21 Great Coram Street.

On July 2nd of this year Perkins obtained a patent for "several improvements in generating steam through the better circulation of the water in the boiler," a subject which had received very little scientific attention from engineers up to this time. The superiority of one kind of boiler over another was more often a matter of chance rather than of knowledge and careful planning. Perkins' specification drawing showed a pair of dome top boilers with flat furnace plates from which depend fifty-five iron tubes 3 inches in diameter and one to two feet long, closed at the furnace end and open at their juncture with the bottom of the boiler. Each of these tubes contained concentrically a lesser one of 2 inches diameter, which formed the crux of the invention. The cold water descending through this inner tube was heated by the furnace as it passed up again in the annular space formed

by the two tubes. The principal application of these circulating tubes was for use on existing boilers, carrying only low pressures as exemplified by the drawing shown on Plate XXXIII. It is unlikely that this type of tube was ever used by boilermakers during Perkins' life but its value was appreciated later by Messrs. Merryweather and Son of Long Acre, London, the celebrated manufacturers of fire engines and other equipment.

This particular type of pendulous tube was an essential feature of Merryweather's quick steaming boilers and a patent for these was taken out in 1862. The tube was claimed at the time as the invention of Edward Field, a partner of the firm, and this type has always borne his name. However, except for a trumpet-shaped deflector on the center tube and an extension of length, the design is definitely that of Perkins. A drawing of the Field tube is shown for comparison with two examples of the tubes invented by Perkins. See Plate XXXIV. In the *Engineer* of September 28, 1866, when speaking of the extraordinary efficiency of the Merryweather boiler, it was stated:

> The boiler is constructed on a now well-known principle, invented some years since by Mr. Field, one of the partners in the firm, and has been found to answer admirably, steam being got up and maintained with the greatest facility, while the boiler is eminently safe from explosion, as the failure of a single tube would relieve the greatest pressure which could possibly accumulate.

The foregoing comment, while high praise for this type of boiler, is a reprehensible misstatement as to who was the true inventor. John Bourne in his work *Steam, Air and Gas Engines* published in 1878, says: "Tubes of this kind under the name of 'Field tubes' are now used in boilers to a considerable extent. But the real author of the system is Perkins."

In his patent of 1831, Perkins also described a method of circulating the water in boilers of various shapes by means of curved baffle plates or partitions, "thus causing the water to take up the heat from the inner surface of steam boilers or generators and thereby producing a rapid generation of steam with less injury to the metal or material of the boiler."

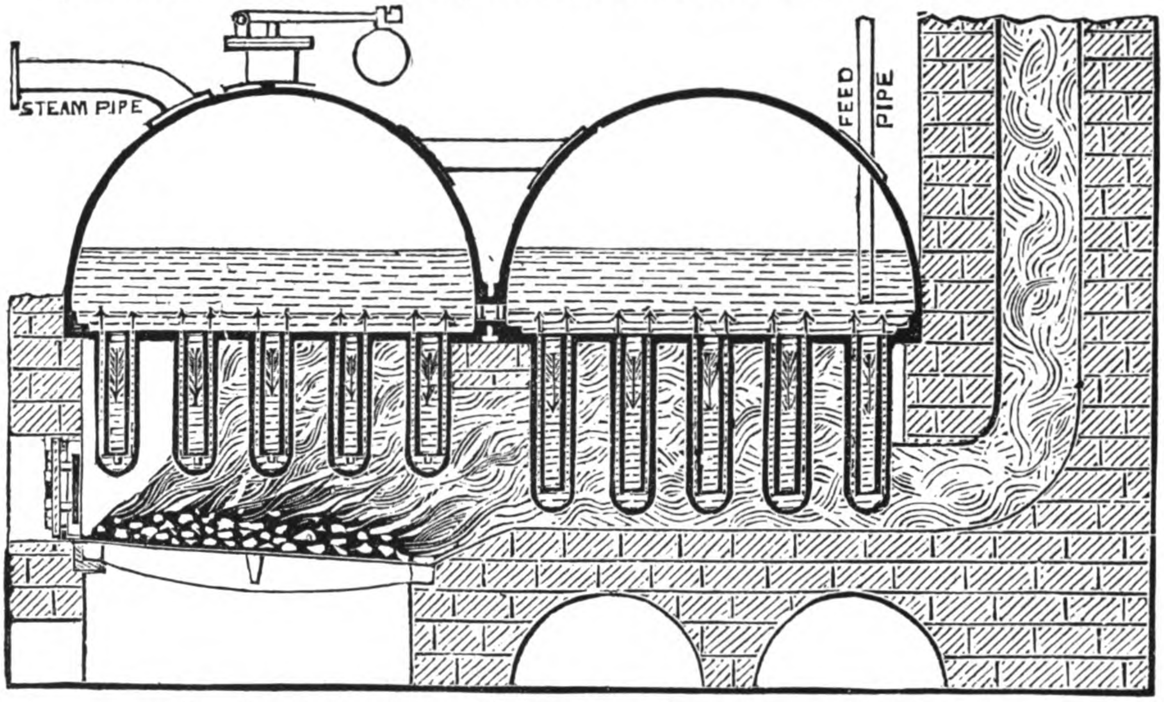
In 1832 Perkins amplified his patent specification by issuing a small brochure, entitled *Steam Navigation Improvements,* of twenty-one pages with a plate and a comparative table showing the advantage of using his circulating tubes in a Boulton and Watt wagon boiler, of which there were great numbers still in use.

The engraving of the Perkins pendulous circulating tubes and a key to the drawing are shown on Plate XXXIII. The title page reads "Part I—The Boiler," and no doubt Perkins intended to issue Part II to cover the marine steam engine but no trace of such a subsequent publication has come to light.

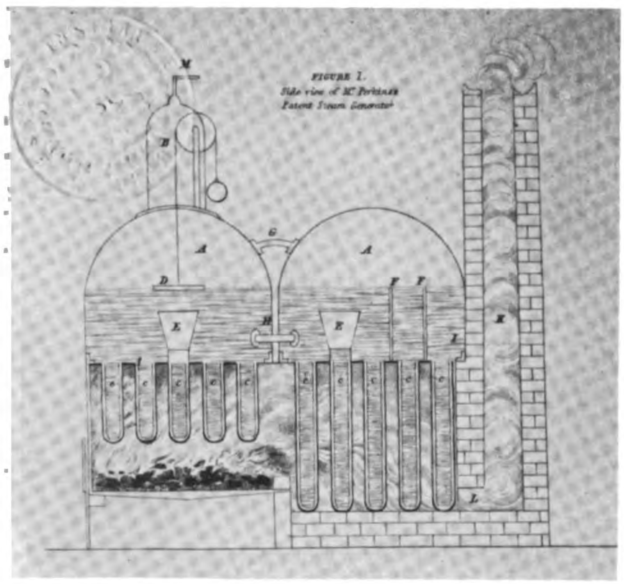
On May 3, 1832, Perkins had a short paper read before the Royal Society, entitled *An Account of Certain New Facts and Observations on the Production of Steam,*[179] which was based on his recent experiments in the circulation of water in boilers. He stated that he had observed that when water was dropped on the surface of melted iron, the water was little affected, owing to the cushion of steam, though when this experiment was reversed and a drop of melted iron was plunged into water, it exploded violently with much visible steam. The deduction made from this was that water must be kept in close contact with the heated

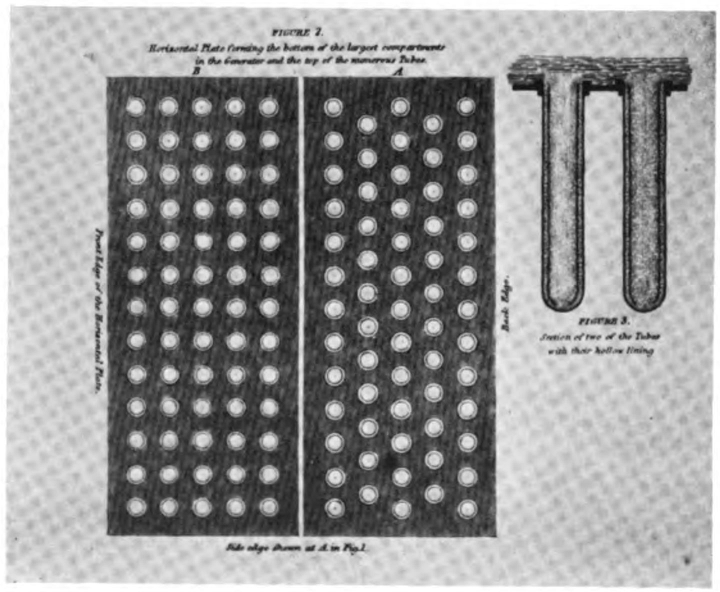
[179] Proceedings of the Royal Society, 1831-1832.

Jacob Perkins' Method of Generating Steam by means of Pendulous Circulating Water Tubes.



From Burgh's *Treatise on Boilers*, drawn from the patent specification of 1831.





Reproduced by courtesy of The Essex Institute. From Perkins' pamphlet *Steam Navigation*, 1832.

AA —The steam chambers of a low pressure boiler.
B —The steam dome to which is fixed the steam pipe and safety valve.
CC —The circulating water tubes of varying lengths.
D —The float stone to indicate the level of the water.
EE —"Recipients" to collect deposits found in the water.
FF —Partitions of wood to promote circulation.
GH—The equalizing pipes between the two boilers for the steam and water.

metal to obtain from it, in the shortest time, the greatest quantity of steam. The practical solution to this desired end was incorporated by Perkins in his patent of July 2, 1831, as exemplified by his use of partitions to compel a closer contact and quicker circulation of the water over the heated boiler plates.

Shortly after the foregoing patent, another was filed on August 27, 1831, covering an apparatus for boiling and evaporating liquids and especially adapted to boiling wort, which was the unfermented infusion of malt which when boiled with hops is known to brewers as "Hopped wort." This invention utilized the same principle of circulators for agitating the wort as was employed in the preceding patent. One of the troublesome problems found when boiling a great mass of semisolid material, such as hops, was to prevent them from clogging on the bottom of the boiling pan and thereby overheating the copper plates even to the point of melting. Mechanically driven paddles for stirring the mixture were already in use in many breweries, but a vigorous and natural circulation during boiling was most to be desired, the principle of which is shown on Plate XXXIV.

The same year, 1831, on July 3rd, Angier March Perkins filed his first patent, the forerunner of a dozen or more he took out in connection with his professional career as a heating engineer. This invention was for "improvements in apparatus used for conveying water for heating purposes." His apparatus was first erected at the villa of J. Horsley Palmer at Fulham in 1832. It was used for forcing grapes in wintertime and is described by Angier Perkins as a brick furnace and boiler which could be regulated to maintain an equal temperature for any number of hours.

Another heating plant was erected in the Guardian Fire office at No. 11 Lombard Street, London, the same year. The radiating surface of these hot-water plants was 400 to 1,000 feet of ¾-inch pipe, according to the space to be warmed.[180]

During the three years that Angier March Perkins had been in business in Harpur Street, it is evident that he had done well and it was natural that he should wish to establish his own home. He was then 32 years old. Sometime during the year 1831 he married Miss Julia Georgiana Brown at St. George the Martyr Church in Queens Square, Bloomsbury, and shortly thereafter the couple started housekeeping at No. 21 Great Coram Street, near Brunswick Square. This location was about half a mile north of Angier Perkins' office on Harpur Street and about an equal distance south of the Gray's Inn Road premises which Jacob Perkins occupied about this time for the continuation of his steam engine

---

[180] The Romans used hot water pipes to a certain extent for heating parts of their public baths and in more modern times it is recorded that in 1777 a Monsieur Bonnemain in France used a circulating hot-water system for hatching chickens. The Marquis de Chabannes while in England made the same application in 1817, for heating a conservatory. Little or nothing had been attempted anywhere toward making people's houses warm and comfortable in the winter except by small individual stoves and open fireplaces. The earliest record of steam heating is that made by James Watt in 1784, in his house at Harpers Hill, Birmingham. The radiator was a simple box made from tin plate, supplied from a small low pressure boiler and was used to warm his study and drawing office. The radiation from the polished tin did not prove very efficient. Another early attempt to use steam for heating was in the country house of John Soane, the architect at Tryingham, Buckinghamshire, about 1797. Soane was knighted in 1831 and in that year he installed a small high pressure steam heating system with radiating pipes in his town house at Lincoln's Inn Fields. Matthew Murray, who is mentioned in these pages, heated his house in 1804 by steam from his manufactory near by. His house, Holbeck Lodge, was locally known as Steam Hall. In America the first mention of warming by steam was in the Middletown Woolen Manufacturing Company, in Connecticut in 1812. The exhaust from the steam engine passed through copper pipes up and down through the factory floors on a principle advocated by Oliver Evans about 1804.

business. In 1832, according to the London directory, the name Perkins and Company, Engineers, disappeared from the Regent's Park location and it then appeared at No. 6 Francis Street, Gray's Inn Road, and thus continued until 1837, which was about the time that Jacob Perkins retired from active business. It might be inferred from this change of address that Jacob Perkins and his son, Angier, now shared the Francis Street premises, as by this period Angier would have required manufacturing space for his own growing business.[181] Angier, however, is not listed in the London directory at all until 1838 when the following appears: "Perkins—Angier March, engineer, Patent Hot-water Apparatus Manufactory, 6 Francis Street, Regent's Square, Gray's Inn Road." and thus continued long after Jacob Perkins' death in 1849.

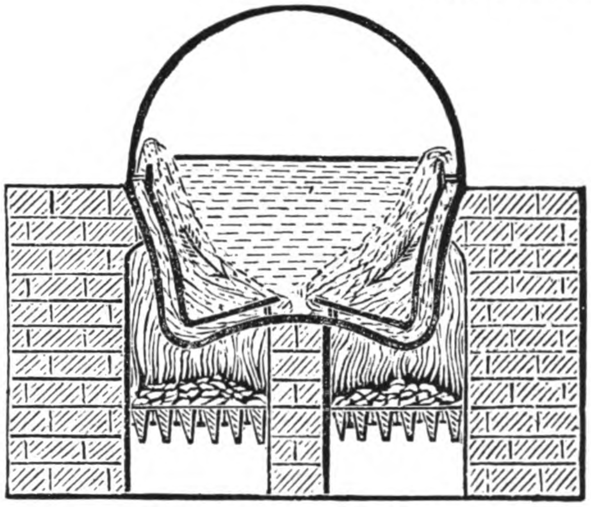
In the abridgments of British patents is to be found, dated June 9, 1832, a patent for "Blowing and Exhausting Air, Applicable to Various Purposes." No specification nor drawing of this invention of Perkins now seems to exist. He had at about this time turned his attention to locomotive matters and there is some evidence that this particular patent covered a method of using a rotary fan in the chimney or smokebox of locomotives. See Plate XXXVIII. This was in lieu of the usual blast pipe which was noisy and created a certain amount of back pressure in the cylinders, which a fan—if it had proved practical—would have obviated.

At about the time of this patent Perkins became engaged in some important experiments with his circulators for Robert Stephenson and Company for preventing the excessive deterioration of the copper fire tubes of their locomotives, known as the "Planet" class.[182] These engines—see Plate XXXV—were the first to have inside cylinders placed forward in the lower part of the smokebox. This type of locomotive was very successful, but a great deal of alteration of parts and minor changes generally were experimented with between the years 1830 and 1835. It is a little difficult to understand just why Perkins was engaged by the Stephensons. They could scarcely have altered their opinion of him as a competent steam engineer during the decade which had passed, especially when it is remembered that as early as 1823 they had expressed themselves as believing that Perkins knew nothing about steam engines. The only answer is that the Stephensons were really desperate for some remedy to overcome the troublesome and expensive conditions confronting them through burst boiler tubes and hoped that Perkins might have the solution. In those days copper and brass pipe were not drawn in one piece, but the metal was hammered to shape on a mandrel and the lapped joint soldered. The inherent weakness of this method of construction is evident when exposed to intense heat and defective circulation. Copper has a very high heat conductivity and to increase the steaming qualities of their "Planet" engines, the Stephensons used at this time copper exclusively for the tubes and in a few cases, for the fireboxes as well. But it was soon discovered that the soft copper both wore and burned out very rapidly. It is recorded that the *Venus*, which was one of the newer

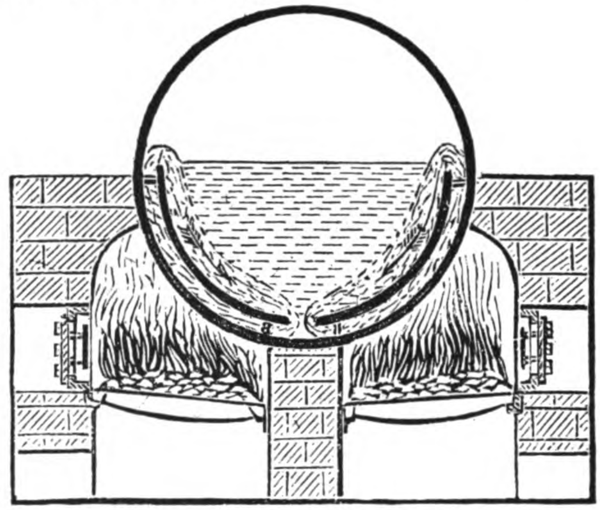
[181] The several changes of business addresses mentioned here of Jacob Perkins and his son, Angier March, cannot be specifically pinned down to the exact year. There is such a complete lack of all letters and other documents dating from this period that only inferences can be drawn as to what kind of business and manufacturing was in progress at any given time.

[182] The first locomotive to be called "Planet" from which this class takes its name, was completed in October, 1830. However many engines of this type were built bearing quite irrelevant titles. The locomotives which were named for the planets were all built in 1831, namely, *Mercury* and *Mars* in January, *Jupiter* in February and *Venus* and *Saturn* in April, and the *Sun* in the same month.

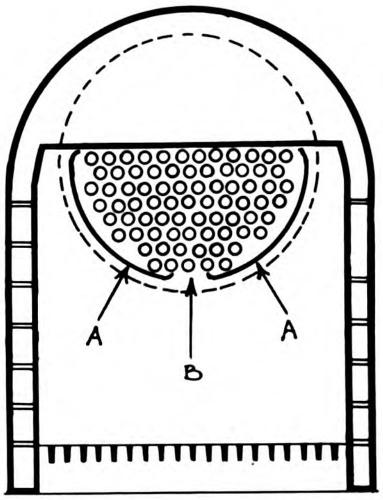
Jacob Perkins' Patent Circulator Linings for Boilers. Various Applications.



The circulator plates applied to a low pressure steam boiler.



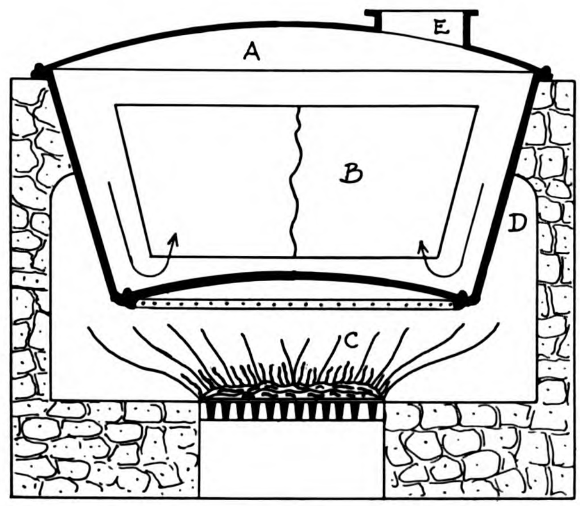
The circulator plates applied to an externally fired, high pressure boiler.



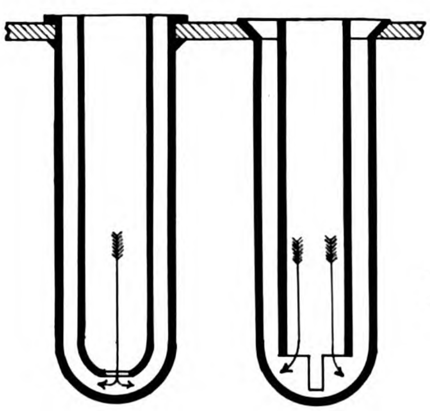
As applied to the *Planet* locomotives on the Liverpool and Manchester Railway.

AA—The circulator plates separating the tubes from the boiler shell.

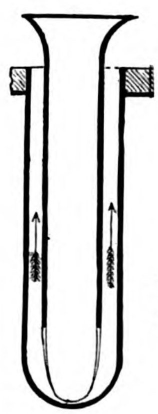
B —The opening through which the cold water passes upward through the tubes.



The circulator as used when boiling semi-solid liquors, such as hops. A—The copper boiling pan containing the circulating cone B, of thin copper. C—The furnace, and the flue D. The manhole for charging the pan is at E.



The Perkins Circulating Water Tubes from original drawings of 1831 and 1832.



The "Field" Water Tube, patented by Merryweather and Sons, in 1862.

engines of the "Planet" class, after only 8,000 miles of service on the Liverpool and Manchester Railway, began to burst tubes at the rate of three or four a day and the problem thus became a very real one, for the engine drivers in general and for Robert Stephenson in particular, who was the engineer of locomotive construction and responsible to the railway company. It appears that during the latter part of 1832 Perkins was provided with one of the company's locomotives with which to experiment, probably the *Venus* already mentioned. From this it may be inferred that Perkins was up in Newcastle-upon-Tyne at the Stephensons' locomotive works, located at Forth Street, for sometime. To insert Perkins' circulators[183] into the boiler between the outer tubes and the boiler shell required the tube plate in the smokebox to be removed and then reriveted back again. The locomotive so altered was put back into regular service in January, 1833. The first enthusiastic reports claimed that the locomotive "did three hundred and sixty successive journeys between Manchester and Liverpool and ran 20,000 miles without deterioration of the tubes, which then appeared to be as free from corrosion as when they were first installed and this with a saving of forty tons of fuel." From an account in the *Centenary History of the Liverpool and Manchester Railway* it appears that the *Venus* and probably four other engines were fitted with Perkins' circulating device. In connection with Perkins' current interest in locomotives, he patented on November 20, 1832, "a method of preserving copper from oxidation caused by heat, especially in copper locomotive tubes." Perkins said in his specification that he used an alloy of 2/3 copper and 1/3 zinc melted together and then applied to the heated copper surface by means of the usual fluxes. Presumably only the outside surface of the tubes that were in contact with the water would have been treated, this with the idea of counteracting any galvanic action set up by impurities in the boiler.

At a meeting of the Institution of Civil Engineers on February 26, 1833, Robert Stephenson stated that: "The trials with Perkins' patent circulators had not been prosecuted far enough to justify a decided opinion as to their utility"; and further that "no saving of fuel had yet been effected through this means"; but that "it was expected the wear and tear of the boiler-plates would be considerably reduced." From this non-committal statement by Stephenson, it may be deduced that Perkins' circulators would have proved effective in some manner if they had received a more prolonged test, and the evidence in their favor might then have been more conclusive. It is believed that at least four locomotives were altered to Perkins' method but as far as the *Venus* was concerned, by February 15, 1833, it was listed on the Company's books as "done" or worn out, having a total of 35,130 miles to its credit.

Alexander Gordon, the civil engineer, who wrote as a contemporary of this period, in his treatise upon *Elemental Locomotion*, remarks:[184]

> This principle has been applied to boilers on the Liverpool and Manchester railway with success, as it would appear from the transactions which I minuted of the Institution of Civil Engineers. The recent improvements proposed for boilers by Mr. Perkins were shortly stated by a member. He had seen the

[183] This device was an adaption based on Perkins' patent of July 2, 1831. As applied to locomotives it was referred to as "Perkins' Circulators" or as "Perkins' lining for the firebox" by the Stephensons. There is no evidence, however, to show that the circulators were ever fitted to the water spaces of the firebox but that they were introduced down the whole length of the inside of the boiler shell and curved to fit the water space on each side. The fire tubes of the "Planet" engines were 1⅝ inches in diameter and about 7 feet long. They varied in number from seventy-six to one hundred and twenty-four and each copper tube cost £1.

[184] *A Treatise on Elemental Locomotion*, third edition, 1836, pp. 155-156.

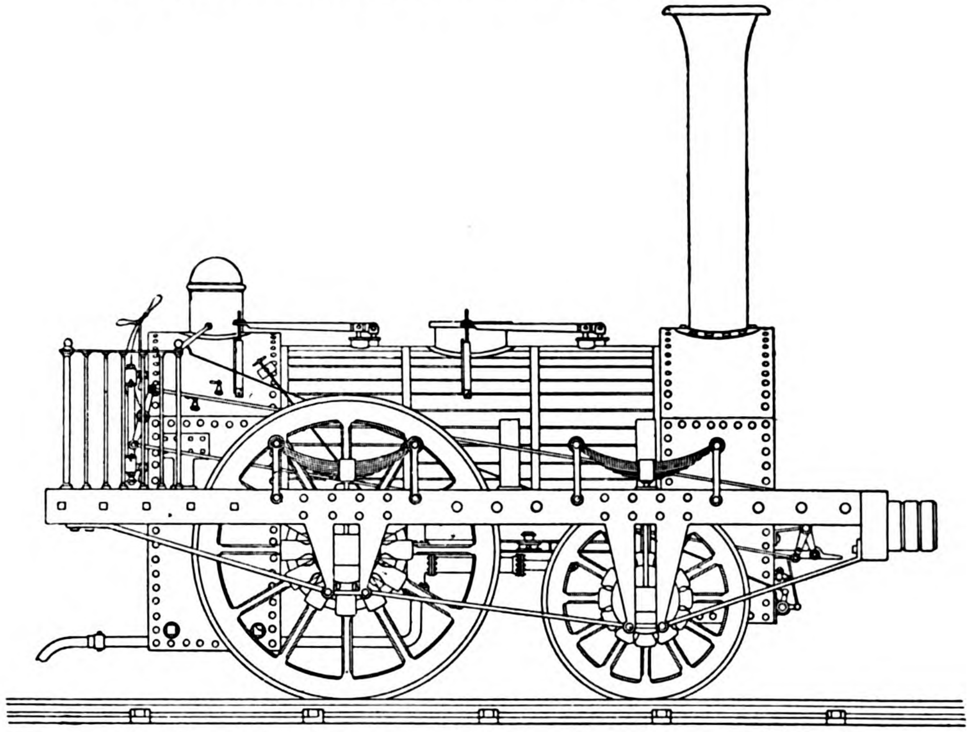
state of the flue-tubes used in the Liverpool and Manchester locomotives, both before and after a run of 3,000 or 4,000 miles. Whilst the destructive chemical and mechanical effects on the interior of these flues were manifest in every tube, before the side lining was introduced by Mr. Perkins, flue-tubes with Mr. Perkins' lining between them and the sides of the boiler, had travelled the same distance with very little deterioration, and that only a mechanical deterioration. Flue-tubes taken out of a boiler which had not the lining, after the work of 3,000 miles, were often worn so thin as to collapse and burst, or if they did not collapse, were often worn very thin,—at least half of the substance being worn away in the interior of the pipes. The action of the heat and the grinding of cinders, as they pass along these copper tubes, by the intensity of the blast, often reduced the tubes to the thickness of paper. Other members were of the opinion that the crowded state of these flue-tubes prevented the circulation, and globules of steam being formed could not get away, but clung to the tubes, and thus, by the *non-conducting* steam being on one side of the metal of the tube, whilst an intensity of heat impinged on the other, the burning of the tube was a necessary consequence. Some members maintained that if the outer rows of tubes had been removed, a brisker circulation might have been obtained without using Mr. Perkins' lining, and that this quicker circulation would have kept the water nearer the tubes, to conduct off the heat.

From the evidence given in the foregoing extract, it seems fairly conclusive that Perkins' circulators did materially benefit the boiler circulation and prevent to a large extent the troublesome deterioration of the tubes. If copper had been the only metal available, then Perkins' circulators might have become a necessity to the company for at least a while but shortly after this, hard brass tubes, and in a few cases those of iron, were substituted for those of copper on all the company's locomotives and further trials of Perkins' circulators were dropped. The publicity of Perkins' work for the directors of the Liverpool and Manchester Railway had its repercussions on the other side of the Atlantic. Doubtless some New England sailing master carried the news of his countryman's fame back to Newburyport, for early in 1833 was launched there a fine new vessel of 379 tons, christened the *Jacob Perkins* for the town's most eminent son. This event, while a matter of considerable interest to the citizens, must have proved a somewhat ironic honor to Perkins, for the vessel was built as a full-rigged sailing ship. Evidently at this time the Newburyport shipping interests were not prepared to take any chances with steam, even for a native son.

In this year, 1833, on April 22nd, died Richard Trevithick, the celebrated Cornish engineer and pioneer of high pressure steam. That Perkins never appears to have had any acquaintance with Trevithick is remarkable and the authors are constrained to allude to this significance. After Trevithick's return from his Odyssey to the Peruvian mines in 1827, which had taken eleven of the best years of his life, he came to London about June, 1828, apparently in the capacity of consulting engineer to the St. Catherine Dock Company and here he must have become conversant with the Perkins engine trials at the excavations the year before, and also of Perkins' well advanced plans to adapting his engine to marine purposes. Yet in all Trevithick's letters, and he was a voluminous writer, he has never mentioned Perkins' name or work. Was this omission merely a gesture of professional reticence or did he feel that Perkins' steam experiments were of no practical value in the light of his own experience?

During the period under consideration, many events were happening in Perkins' domestic life which must have had great effect upon his plans and actions. On November 14, 1832, Angier March Perkins' first child was born, a boy, who was named Angier Greenleaf. The following year, on September 29, 1833 Perkins' third daughter, Louisa Jane, died at Tunbridge Wells after a long illness, one of the "charming daughters" mentioned

A *Planet* Class Locomotive used on the Liverpool and Manchester Railway.
One of several to which Perkins' Circulators were applied in 1832.



Reproduced from *A Century of Locomotive Building by Robert Stephenson and Co.*

Jacob Perkins
Aged about 67 years

From a bust in the possession of Messrs. Perkins, Bacon and Co., Ltd. The original history and purpose of this bust is not known nor who the sculptor was. It has, as long as can be remembered by surviving members of the firm, been in the possession of Messrs. Perkins, Bacon and Co. There is, in the authors' opinion, an explanation of when and why the bust was made. This was probably about 1833, to place in the entrance hall of The Adelaide Gallery of Practical Science.

by Samuel G. Goodrich some years before, who lived to be only 32 years old. A second son was born to Angier March Perkins on May 8, 1834, this being Loftus, who was destined to become quite as famous in his line of work[185] as his father and grandfather were in theirs. Both of these sons were presumably born at the family home in Great Coram Street. A deep shadow was cast upon the family about this time by the relentless progress of the disease which had affected Ebenezer Perkins, Jacob's eldest son, who had come to England with him so full of hope and promise in 1819 and it was at length decided that Ebenezer had better return to Massachusetts in the faint hope that the long sea voyage and his native land might help his failing strength. To quote the simple pathetic words of Angier March Perkins in his private memoirs "my brother returned to Newburyport to die. Thus I was left with my father, mother and three sisters in England." The exact date of Ebenezer Perkins' return to America is not known, but from his brother's words it may be inferred to have occurred before 1830 and prior to Angier's marriage. The change was evidently in a measure beneficial, as Ebenezer lived for several years longer.

About Jacob Perkins' brother, Abraham, in America, something further may be recorded. It transpires that Abraham Perkins, who had continued the engraving business at Newburyport after his brother's expatriation, had sold the house on Fruit Street during a difficult financial period of the firm. It is well known that Abraham continued to print most of the notes used by the banks of Maine, New Hampshire and Massachusetts from his brother's plates, until well after 1825. It is therefore very probable that Abraham, even after the sale of the house, still retained the workshop on Fruit Street as his engraving plant. From an advertisement in the *Daily Evening Transcript* of Boston, dated March 9, 1833, it appeared that Abraham was then about to remove the engraving business to Boston:

THE BANKING INSTITUTIONS in New England, are respectfully informed that the subscribers have formed a Copartnership under the firm of the N. ENGLAND BANK NOTE CO, for the purpose of engraving and printing Bank Notes. Their establishment (now in Newburyport) will be removed to the city of Boston, and located in some building containing secure and fire-proof vaults for the safe deposit of plates and dies, which shall at all times be subject to the inspection of any committee appointed by the Banks for the prevention and detection of counterfeits.

The subscribers have spared no expense in procuring Machinery of the latest improvements and of the most perfect kind. The assistance of the most skilful artists of this city, of New York, and

---

[185] Loftus Perkins brought to his professional work of engineering all the energy and brilliance of mind possessed by his grandfather plus a far greater appreciation of the practical difficulties involved. It is beyond the scope of this volume to more than touch upon the life of Loftus Perkins and the following brief mention of his work will have to suffice. As early as 1859, though then only twenty-five years old, he had designed an engine to work with a pressure of 600 pounds and under his direction several seagoing vessels were equipped with his improved engines and fast steaming boilers. These units followed very closely along the lines developed by his grandfather, Jacob Perkins, thirty years before. The alloyed metallic piston which required no lubrication was brought into practical use on these and subsequent engines. In 1871-1873 he carried out successful experiments with a steam tractor powered by his high pressure system; also the several outstanding improvements to condensers and evaporating plants (1877) were but a part of Loftus Perkins' contributions to the progress of steam engineering. The most outstanding demonstration of his work was the seagoing yacht *Anthracite* which made its successful voyage to the United States and return in 1880. This little vessel of barely 87 feet in length steamed 3,316 miles with a consumption of only 25 tons of coal. The engine working under a pressure averaging 375 pounds which was phenomenal for those days. Loftus Perkins in his later years turned to the subject of improving mechanical refrigeration with his characteristic energy and without doubt the long hours of overwork on these problems greatly contributed to his untimely death on April 27, 1891, at the comparatively early age of 57.

Philadelphia, has been secured, and every arrangement made to render their work excellent, and to place every possible obstacle in the way of the counterfeiter.

ABRAM PERKINS,
W. S. PENDLETON,
HAZEN MORSE,
NATH'L PERKINS.

Nathanial Perkins, the fourth partner mentioned in this advertisement, was a son of Abraham. With the decision to remove the business from Newburyport to Boston, Abraham Perkins decided to buy back the dwelling part of the Fruit Street premises and the transfer of this was made to him on September 11, 1832, and Abraham Perkins continued to live here until his death in 1839.

It seemed as if the New England Bank Note Company was not to be without competition, for by a coincidence (which, however, was probably more by design than accident) the firm of Annin and Smith also issued about the same time a statement in the *Transcript* which said in part:

Annin & Smith, Bank Note Engravers, No. 70 State Street, Boston, Inform their friends and the public that, by their arrangements with the well known and long established house of Draper, Underwood, Bald & Spencer, (formerly Murray, Draper, Fairman & Co.) of Philadelphia, they are now in readiness to execute Bank Notes combining every modern improvement which has been found of real advantage as a security against counterfeits—at the shortest notice.

It will be noted in passing, that the parent firm in Philadelphia had undergone some change in its personnel since Gideon Fairman's death in 1827, as by this time Asa Spencer was a partner in the firm.

Of Abraham Perkins there is but little more to tell. This conscientious and industrious brother of Jacob Perkins was, as late as 1834, still negotiating with Jacob's Massachusetts creditors, twenty-four in number, and in a document containing a schedule of these debts, dated January 29th of that year, Abraham says: [186] "All of these marked 'x' [twenty-two in number] are wholly settled with and the others have accepted a part of their demands."

Of the many and varied machines which Perkins evolved from his fertile mind, none redounded more to his credit than his inception of a refrigerating apparatus which could manufacture ice in bulk by mechanical power alone. Artificial ice as an experiment had been made in America by simple methods by Dr. William Cullen as early as 1755. Cullen placed a beaker of ether[187] in a bowl of water under the bell of his pneumatic pump and by exhausting, caused the ether to boil in vacuum and at the same time the vapor was drawn off the water was found to be frozen. In 1810 Sir John Leslie succeeded in making small lumps of ice of one or one and one-half pounds weight in any quantity, by using sulphuric acid as a refrigerant. The sulphuric acid vapor was introduced into the receiver of an air pump containing pans of water. The acid fumes absorbed the moist air, after which the combined vapor of the acid and the water were pumped out, producing a freezing tempera-

[186] Affidavit, etc., the Perkins Papers, in The Essex Institute.
[187] Ether is a distillation of alcohol and sulphuric acid, known as sulphuric ether. It has a boiling point of 94.1 degrees Fahrenheit and a condensing pressure of about 2½ pounds when the temperature is 84 degrees. Ether condenses during compression and superheats during expansion in a vacuum and is non-corrosive to metals.

ture in the receiver. Practically nothing further was done in the way of making artificial ice until the advent of Perkins' system of mechanical refrigeration for which he obtained a patent on August 14, 1834.

Perkins describes his invention as "Improvements in the Apparatus and Means of Producing Ice, and in Cooling Fluids." The specification is quite short and is accompanied by a single sectional drawing, reproduced on Plate XXXVI. The essential portions of this read:

It is well known that by evaporating volatile fluids from the surfaces of vessels containing other fluids the caloric of the later fluids is reduced, and cools down the temperature, indicated by a thermometer immersed therein; but in so evaporating volatile fluids the same is lost, and hence the application of this process. To produce a considerable degree of cooling effect to fluids requiring that process on a large scale, a large cost is necessary, and hence renders this means of cooling of little practical value. Now the object of my Invention is so to use a volatile fluid that the same (having been evaporated by the heat or caloric contained in the fluid about to be reduced in temperature) shall be condensed and come again into the vessel to be again evaporated and carry off further quantities of caloric. But in order that my Invention may be most fully understood, and carried into effect, I will describe the Drawing hereunto annexed.

DESCRIPTION OF THE DRAWING.

a—is a cistern for containing the water or other fluid from which it is desired to remove the caloric, and thus reduce its temperature, and even produce ice. This vessel should be well covered in and surrounded by a non-conducting material, in order to prevent the atmosphere or surrounding bodies giving off heat to the water or other fluid contained in such system; b—is a vessel which is to contain the volatile fluid to be evaporated, and I chiefly recommend ether as the material to be evaporated, owing to the low degree of temperature at which under ordinary circumstances it becomes aeriform, but under the circumstances hereafter explained it will evaporate at still lower degrees of temperature; c—is an ordinary pump which I term the vapor pump, it being intended to withdraw the vapor as it is generated in the vessel b, and to force it through the refrigerating pipes d contained in the cooling tube e. There is to be a constant supply of cold water to the refrigerating tub or vessel e—, in order to cool down and condense the vapor in the pipes d. f—is a pipe leading from the vessel b to the pump, having a valve to close the entrance into the pump in order to prevent the vapor being forced back into the vessel b—on the return stroke of the piston; g—is a pipe having a valve opening outward from the pump. This pipe g—connects the pump with the refrigerating pipes d—; consequently the vapor on coming into the pump will be forced into the pipes d—, and be there condensed, and thence return again into the vessel b—to be again evaporated. But in order to secure a perfect condensation I employ a valve h—moderately weighted, say about atmospheric pressure, which prevents the return of the condensed ether till the same has become compressed and forced to give off its caloric to the condensing water on the outside of the condensing tubes d. This valve h—is placed between the condenser and the vessel b—, as shown in the Drawing. It will be seen that most of the parts are shown in section in order that their construction may be evident.

Having thus described the nature of my Invention, and the arrangement of apparatus for carrying the same into effect, I will now describe the manner of using the same. The apparatus being arranged as above described, and as shown in the Drawing, I now prepare it for commencing work by filling every part of the apparatus with the volatile liquid to the utter exclusion of the atmospheric air, after which a sufficient quantity of the liquid is drawn off by the small pump attached to the valve—h to make sufficient space for the vapor, say at least one half. The progress of the evaporation of the liquid in the vessel b will depend on the quantity of vapor drawn off by the vapor pump, as well as the quantity of caloric taken up from the liquid surrounding the vessel b—, and thereby will its temperature be cooled down even to freezing.

As indicated by the drawing, the construction of the machine left much to be desired, except in its general principle of action. If used for cooling water only, the arrangement of the expansion chamber b. would serve, but in the event of the chilling process being carried to the point of freezing, it would have been found impossible to remove the ice. The piston of the vapor pump c. would for any prolonged service, have to be extremely well fitted to prevent the escape of the volatile ether on the compression stroke and equally so during the upstroke, to prevent the admission of air into the system. Similar problems to these more often than not have to be overcome by the manufacturing engineer and it is to his long experience and sound mechanical knowledge that success comes to many an invention.

During 1835 the first conception of the refrigerating machine was reduced to a more practical form by John Hague,[188] an engineer of great ability. His manufactory at this time was on Cable Street, Ratcliffe, which is now a part of Stepney. Hague arranged the working parts of Perkins' machine so that it could be driven by power as shown on Plate XXXVI and the freezing pan was made to a shape which enabled the ice to be removed in one piece. Sir Frederick Bramwell, the civil engineer,[189] in a letter to the Society of Arts in 1882,[190] gives an interesting account of his memories of the Perkins ice machine:

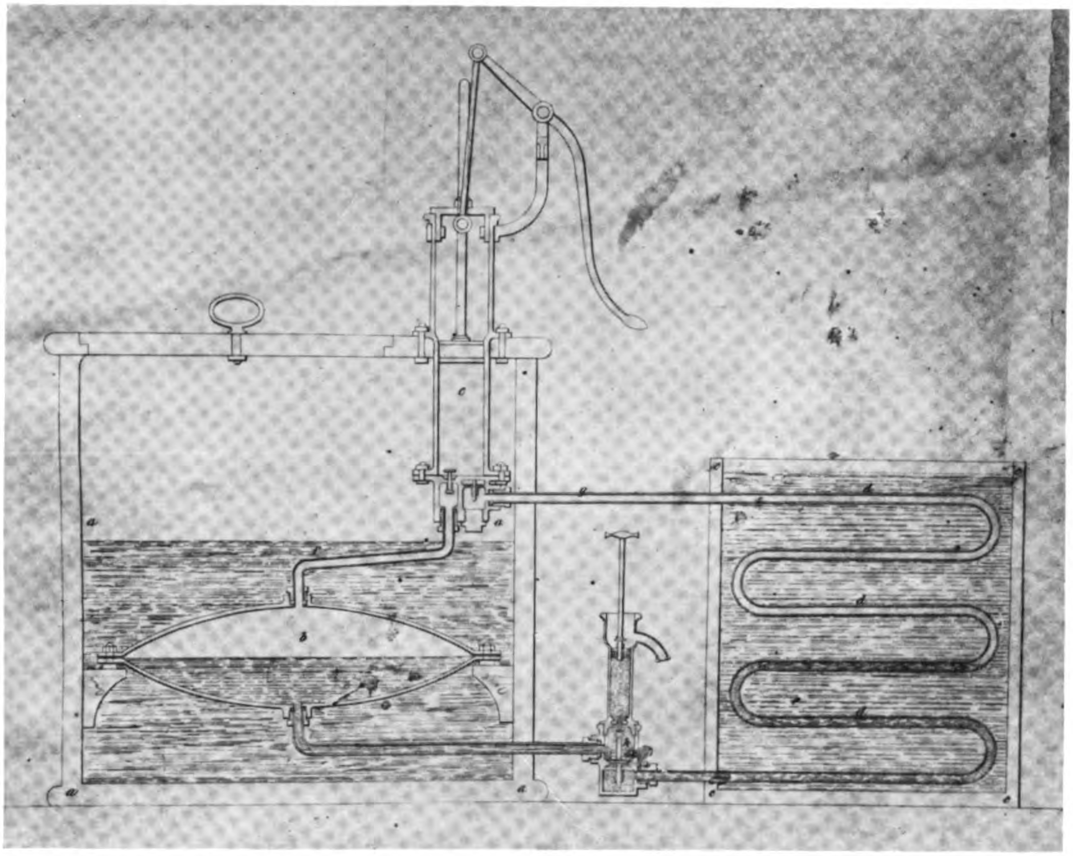
> It has occured to me that it may interest those connected with ice-making, if I were to recall to public attention the invention (patented in 1834 No. 6662) of Mr. Jacob Perkins, the grandfather of our present member of council. A reference to this specification (if anyone could get a copy of it, for it, like many others, is out of print) would show that Mr. Perkins claimed to have invented not the freezing of water, or cooling of bodies by the evaporation of ether or other volatile liquid, but—*the essential thing for commercial purpose—the "apparatus or means, as above described, whereby I am enabled to use volatile fluids for the purpose of producing cooling or freezing of fluids, and yet, at the same time, constantly condensing such volatile fluids, and bringing them again and again into operation, without waste."*
>
> A small machine of this kind was made for Mr. Perkins, by Mr. John Hague, the engineer, and Mr. T. R. Crampton (now, like Mr. Loftus Perkins, a member of your council,) and myself, who were apprentices at that time to Mr. Hague, assisted in its manufacture. It was intended to use sulphuric ether in the machine, but as a matter of fact, it was put to work with the volatile liquid arising from the destructive distillation of caoutchouc, and it succeeded in producing ice, and in doing so in the height of the summer. The apparatus was a small one, carried on a wooden base—according to my recollection, some five feet long by two feet or two feet six inches wide. At one end there was a jacketed copper pan, the interior of which held the water to be frozen, while in the jacket was the volatile liquid and its vapor. The pan was enclosed in a wooden box, containing powdered charcoal as a non-conductor.

[188] John Hague's establishment was close by the site of the old Brunswick Theater which history tells us collapsed in 1828 owing to the weight of a newly erected roof, the accident killing or injuring a large number of people in the audience. Hague was a considerable manufacturer of mint machinery, such as rolling mills, stamping presses and milling machines, for foreign governments which included those of Holland, Prussia and Brazil. He had also been consultant with Henry Maudslay before his death in 1831 on much of the new machinery authorized by the Royal Mint. One of these pieces of machinery designed by Hague and built by Maudslay, Sons and Field, was a powerful drawing machine for equalizing the thickness of the metal strips from which the blanks were punched. In 1827 Hague patented his invention for an atmospherically operated tilt hammer which greatly increased the range of work hitherto performed by this type of machine. He also made dock cranes, and engine hoists for warehouses on the atmospheric or vacuum principle.

[189] Sir Frederick Bramwell, born in London in 1818. In 1856 he became an associate of the Institution of Civil Engineers and in 1884, its president. He was also the president of the British Association in 1888. He died in 1903 at the advanced age of 85. One of the chief activities of his life was the furthering of technical education of working men.

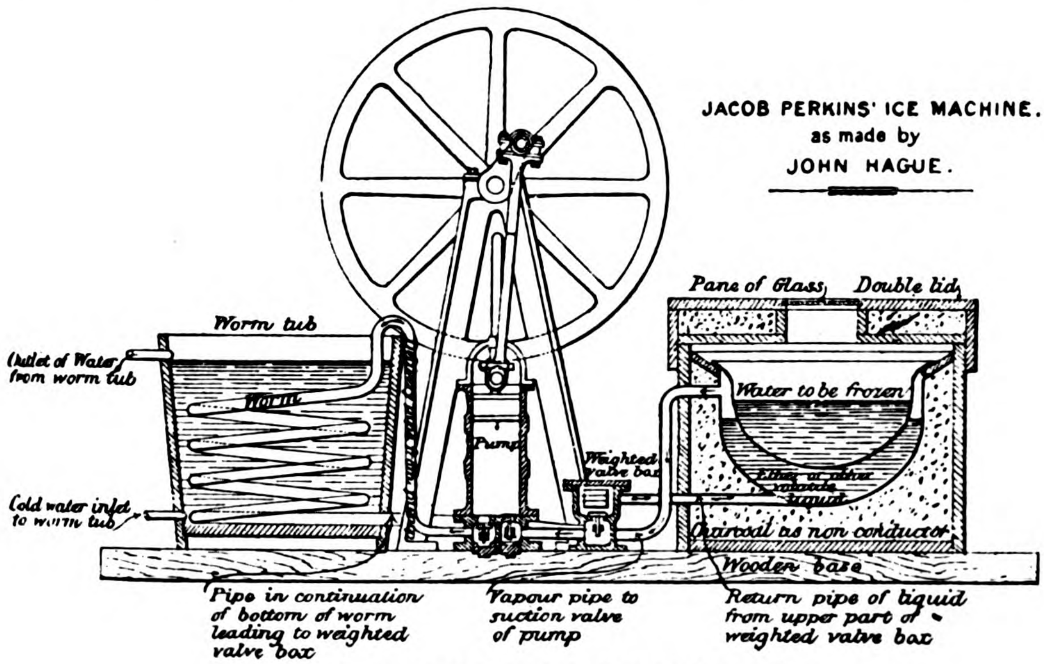
[190] Reprinted in the *Journal of the Society of Arts*. Vol. XXX, p. 77, with a drawing of Perkins' ice machine.

Jacob Perkins' Machine for Producing Artificial Ice, 1834.



From a copy of the specification in the United States Patent Office.

The wooden chest, aaaa, containing the water to be frozen. b—The ether chamber. f—The pipe through which the vapor is drawn into the pump c. g—The pipe through which the vapor is forced into the coil ddd, and condensed by the water in the chest eeee. The liquid ether then passed through the valve h, back into the ether chamber b. The small pump between the wooden chests was used for removing a part of the ether after the system had been completely filled to expel the air. The top of the freezing chest had a removable lid, as shown.



From a drawing in the *Journal of the Society of Arts*, 1882.

From the top of the jacket a pipe was led away to the suction valve of an air pump, fixed in the middle of the wooden base. From the delivery valve of this pump a pipe proceeded to the top of a worm, contained in the worm-tub, supported on the wooden base, at the end opposite to that where the jacketed pan was. The worm-tub was supplied with water, from an inlet at the bottom, and the escape was by an overflow at the top. A pipe in continuation of the lower end of the worm, was connected to the under side of a valve box, in which was a valve loaded to about 15 lbs. to the inch, so that the vapor in the worm was subjected to the pressure, as well as to the cooling influence of the water, and by these means was brought back to a liquid condition. From the upper side of the valve box a pipe proceeded to the bottom of the jacketed pan, to convey the liquor to it, thus completing the circuit.

I send a rough sketch of the apparatus above described, and I also send a tracing of the drawing of Perkins' specification, and a manuscript copy of the specification itself, in order that you may see how closely a practical working machine agreed with the drawing of the specification, the only difference in truth being that, had the machine been made exactly in accordance with the specification drawing, the block of ice must have been sawn asunder before it could have been removed.

In the foregoing letter, Sir Frederick Bramwell lays particular stress not so much on the practical outcome of Perkins' ice machine as on the fact that Perkins was the first to specify a closed circuit of operations by which the refrigerant was used over and over again without loss. If this be the essence of the invention then the basic idea goes farther back, for it may well be supposed that Sir Frederick was not conversant with the work of Oliver Evans along these lines of cooling (and of course, a step further, of freezing) of water thirty years before. The closed system which Evans described in his treatise of 1805 reads unmistakably the same in principle of action as that of Perkins in 1834. Evans described an ether chamber placed in a vessel of water and an air pump to discharge the vapor into a condenser and a pipe from this to return the liquid back to the ether chamber and in conclusion said: ". . . to undergo the same operation; and so on *ad infinitum*." That Evans never pursued this matter further than explaining how it should be done of course removes him from the practical field. But if the claim for a closed system is to be the basis of discovery then in justice the honor must go to Evans. In Appendix H. are included Evans' remarks upon the cooling of liquids and a description of his theoretical machine for accomplishing this end, which can be used for comparison with the Perkins machine.

However, it is on the practical machine that Perkins and Hague built that fame must rest, and about this there are some interesting anecdotes to relate. Sir Frederick Bramwell made the drawing for the Hague ice machine and tells that the first piece of ice made was placed in a blanket and taken by Bramwell, then a young man of seventeen, in a cab to Perkins' house on Great Coram Street where one can imagine the inventor's disappointment when it was unwrapped and found that the ice had completely melted on the journey. In this machine the refrigerant used was not pure ether, as at first mentioned by Perkins in his patent, but a liquid obtained by dissolving crude rubber in ether and then distilling over the volatile constituent. This solution of ether and rubber, or caoutchouc was a varnish used by engravers to preserve their copper and steel plates from oxidation when laid away, so naturally this solution would have suggested itself to Perkins as a refrigerant. Owing to the very pungent odor of this, Perkins proposed to install his ice factory on an anchored barge in the Thames, and drive the compressor by gearing it to paddle wheels worked by the ebb and flow of the tide. This situation would also have provided plenty of water for the ice and cooling of the condenser coils. But of all this nothing came, although the necessity for a plentiful supply of ice was as real then as now. At this time, the ice

industry represented the huge sum of approximately £100,000 a year. This natural ice was often sent as ballast, packed in refuse bark, on the lumber ships from the Baltic ports, and from Greenland there was a regular trade carried on with this frozen commodity. The retail price of ice in London is not known, but a shipment of 180 tons sent to Calcutta from Boston in 1833 fetched three pence per pound. The loss on the long voyage amounted to 80 tons.

The *Encyclopedia Britannica* up to the 11th edition, 1911, generally states under *Jacob Perkins:* "This machine, though never used commercially, is the parent of all modern compression machines." Jacob Perkins' name, however, does not appear in the subsequent editions of the *Britannica.*

This pioneer of all mechanical refrigerators was not developed further either by Perkins, or by his son, Angier, during their ensuing lives. But his gifted grandson, Loftus Perkins, spent his latter years in unremitting labor on what is now known as the automatic ammonia absorption machine, which in its varied and improved forms is the essential necessity of the chilled meat and produce industry.

Jacob Perkins was now nearing 70 years of age and with all his worldly success behind him, for of his many inventions few had brought him in any real financial return except his patent check plate and its ramifications arising from the varied uses of steel engraving. Perkins' gradual withdrawal from professional life began in about 1833 and was practically complete by 1836. Apparently his health was good and his robust constitution unimpaired, but his heart was heavy and sad with the disappointments of the last few years. Sometime after Perkins had realized that he could not carry on with his steam engine experiments to any final worth-while financial conclusions, owing to the death of his financial partner, he turned definitely to an idea that he had been dallying with for some time, that of having a permanent museum to display the sciences and arts of the day, with demonstrations of his own and other inventions, this to be covered by paid admissions which he hoped would yield an adequate return. It is stated in Wheatley and Cunningham's *London Past and Present,* which is a recognized authority, that "the Adelaide Gallery of Practical Science was built by Jacob Perkins, the engineer and opened in 1832 for the exhibition of inventions, works of art, and specimens of novel manufacture." How this venture was financed is not definitely known except that the exhibition was formed into a company about this time. Several subscription soirees were held during 1833 under the patronage of the Duke of Sussex who was also at that time the President of the Royal Society and on these evenings ladies and gentlemen in high society enjoyed "a conversation on some practical application of the sciences." The Gallery was at the lower end of Adelaide Street, now Agar Street,[191] which runs north at 429 Strand to 7 Chandos Street. At the upper end of Adelaide Street was the newly built Charing Cross Hospital, the first stone of which was laid in 1831. The exact date of the opening of the exhibition is not definitely

[191] Agar Street was named for G. J. Agar-Ellis, Commissioner of Woods and Forests, who laid out this street in 1830 as part of the improvements authorized by Parliament in 1829. This section of London at the west end of the Strand and around Charing Cross, represented at this time a strange mixture of splendor and squalor. S. G. Goodrich speaking of the neighborhood as it was in 1825 said: "At that time Charing Cross was a filthy, triangular thoroughfare, a stand for hackney coaches, and a grand panorama of show-bills, posted over the surrounding walls, with the King's Mews in the immediate vicinity." Trafalgar Square now the western end of the Strand, was completed in 1843 as a part of these improvements.

known but it was undoubtedly going strong by 1834, for in the London directory of that year it is advertised as:

> Grand Exhibition. National Gallery of Practical Science, Adelaide Street, and Lowther Arcade, West Strand. Admission 1/— daily, Ten to dusk, displaying an extensive variety of objects of general interest and amusement:—Steam Gun: Steam Boat Models propelled on water; Steam Carriages for Railways; Magnet of extraordinary power, producing brilliant sparks; Electro-Magnet, Cooking by Gas, Distillation of Spirit from Bread, Water compressed by immense power, Fossils, Instrumental Music, magnificent Paintings, etc. etc. Annual Admission Ticket £1.

In this notice the exhibition is mentioned as being close by the Lowther Arcade, which was designed and built between 1830 and 1832. The arcade had a glass roof 240 feet long and connected the Strand with St. Martin's churchyard in that day. What memories one of the authors at least has of this Aladdin's cave, for by the late eighties it was a glorified toy shop. The arcade was finally pulled down about 1903 to make way for the inevitable improvements to the Strand.

By 1833 the steam gun had been sent to the Adelaide Gallery from Regent's Park at the time that Perkins removed his workshop to No. 6 Francis Street, and demonstrations of the gun's power were held daily at stated times.

John Timbs, the historian, relates in his *Curiosities of London* his early impressions of one of these exhibitions of the gun:

> The Adelaide Gallery of Practical Science, Agar Street, Strand, was built by Jacob Perkins the engineer, and opened by a society in 1832 for the exhibition of Models of Inventions, . . . the compression of water and the Steam Gun were exhibited here, propelling balls, with four times greater force than that of gunpowder, the steam being raised to from 300 to 500 lbs. to the square inch; the balls, on reaching the cast-iron target, fired at a distance of 100 feet, were reduced to the substance of tin foil. It was possible to propell 420 balls in a minute or 25,200 balls in an hour; and the gun was promised to mow down a regiment in less than ten minutes. The Duke of Wellington predicted its failure in warfare.

Even if Perkins' steam gun was considered a failure for the purposes of war (for that matter, it had never had a chance to be tried) it earned plenty of money for the gallery as a thrilling display.

The following queer little book was recently brought to the authors' notice. It is called *Old Humphrey's Walks in London* and was published by the Religious Tract Company sometime about 1844. Old Humphrey must have been a pestiferous old humbug, with his habit of moralizing over everything he saw—however, he did enjoy himself at the Adelaide Gallery and had a good deal to say about it, so a few extracts, stripped of the moral digressions, may be found of interest:

> Did you ever visit the Royal Adelaide Gallery? if not, thither will we bend our steps . . . . my business will be to implant in your memory useful knowledge, and to excite in your mind right feelings.
>
> We have passed the crowded Strand, continues Old Humphrey, we have walked along the Lowther Arcade; we have entered the Long Room of the Institution with a catalogue in our hands; and now, what use can we make of the *models*, the *magnets*, the *steam-engines*, *boats and carriages;* the *fire-escapes*, *air-pumps*, *safety-lamps and hydrometers;* the *life-boats*, *rudders*, *anchors*, *paddles and paddle-wheels:* the *rafts*, *blow-pipes*, *gasmeters*, and *eletrifying machines?* . . . . Look at

that model of *Eddystone lighthouse*. . . . Here is a *life-preserver*, meant to be thrown into the sea when a sailor falls overboard. . . . Hark! that flourish of trumpets announces that the *steam-gun* is about to pour its stream of leaden bullets against the iron target. What a reverberation! what wondrous rapidity! Seventy balls have burst forth in four seconds, and twenty-five thousand might be discharged in an hour. Cannot men destroy each other fast enough in their ruthless wars, that such a murderous weapon as this should be required? Had the steam-gun been the only invention of its talented constructor, he would scarcely be to be envied; but society is indebted to him for many inventions of less questionable utility.

Come back! here is a cluster of curiosities—a model of a new *anchor*, an *improved rudder*, a *plan for preventing ships foundering at sea*, and a *shipwreck-arrow*, to hold communication with a vessel in distress.

. . . . We must not omit seeing the *combustion of steel*, for it is a very curious, and considered, also, a very mysterious process. . . . . . Here are a cluster of useful inventions—The *water-filter*, rendering drinkable that which, without it, would be comparatively useless— The *safety-rein* to curb the unruly steed when he breaks away with his rider— The *stomach-pump*, to remove poison or any other injurious liquid from the stomach— The *apparatus for giving notice when a ship drags her anchor*, an invention which may be very useful to mariners— The *safety-lamp*, to protect the miner in his dangerous employment from the sudden explosion of foul air.

. . . . Do you hear? Notice is given that the *grand oxohydrogen microscope* is about to be exhibited. . . . . Will you be electrified? The shock given from the two basins of water is very slight, but that from the pieces of metal is tolerably sharp.

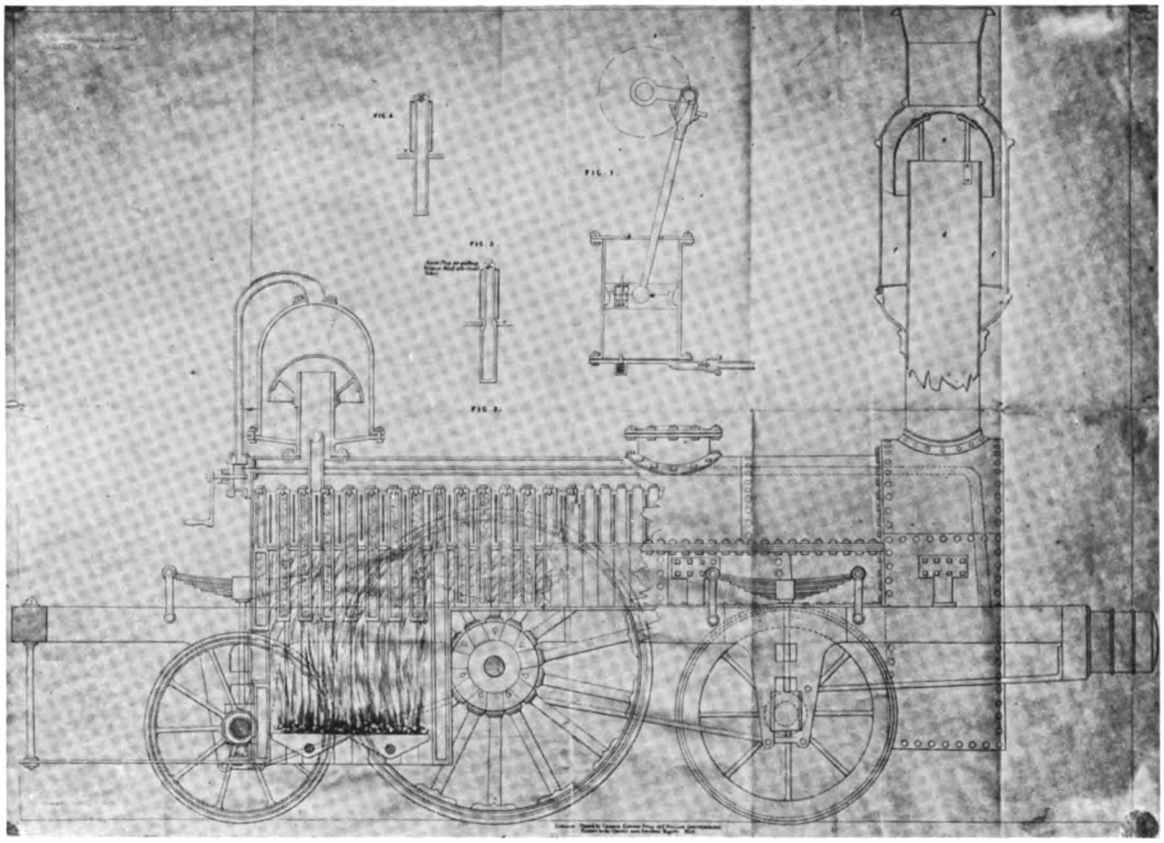
. . . . The *tapestry*, the *paintings*, the *musical instruments*, the *casts*, the *carvings* and the *mosaic tables*, will abundantly recompense you for the trouble of coming again; the *printing* and *weaving* should be dwelt upon; the *microscopes*, *kaleidoscopes*, *prisms*, and unnumbered curiosities will amuse you; the *chemical lecture* must not be lost. The *Daguerrotype* and *electrotype portraits* must be inspected with care, and then you will have a rich treat in the exhibition of paintings called the Kalorama. The paintings are in the new relievo style and their effect is excellent.

If the "Royal Adelaide Gallery" gave such joy to old Humphrey (whoever the creator of this character might have been) how much more must have been the pleasure and interest it all afforded Perkins in his declining years. We can almost see him leaving his son's house in Great Coram Street for a visit there. His long frock coat with its decided waist buttoned tightly around his short, compact figure, light cloth trousers with shoe straps buckled under the heels and upon his head a tall, stiff and very fuzzy hat. At the corner of Woburn Place he would have hailed a horse cab, redolent of the stables and carpeted with dubious straw and entering, would have jogged on down past peaceful Russell Square toward High Holborn. Then, rattling over the cobblestones of this busy thoroughfare to Chancery Lane and so on south to Fleet Street. The cab would be told not to wait as Perkins' visit to No. 69 might be prolonged. Business letters to read, news from America, the mooted possibility of the new penny postage stamp Act, a chat with Henry Petch,[192] the new partner since 1834, a consultation with his son-in-law over some mechanical improvement to the roller printing presses. And then Perkins would have been ready to go. Another cab would have been hailed or perhaps for such a short distance up the Strand, one of Shillibeer's new omnibuses, recently introduced into London from Paris, would have sufficed. More rattling and bumping down the uneven stone paving of Fleet Street, under the ancient arch of Temple Bar and so into the Strand to Adelaide Street.

The doorkeeper, probably an old veteran of the Napoleonic wars, would have touched

[192] Henry Phillipson Petch had joined the firm in 1823 as an engraver and became a partner in 1834. He remained with the firm until his death in June of 1852.

The hermetically sealed tubes applied to a locomotive designed by Jacob Perkins, in 1836.



From a copy obtained through the Patent Office Library, London.

Fig. 1—One of the cylinders with the piston a, and the equilibrium valve. b—A slot in the cylinder head for the connecting rod and waste steam to pass. In the lower cylinder head is the steam pipe and the spring plug to close the equilibrium valve. Fig. 2—The hermetically sealed tube assembly in the locomotive boiler. Figs. 3 and 4—Construction of the individual tubes. The curved baffle plate e, over the chimney d, is to deflect sparks and cinders into the receiver ff.

his hat with a "Fine day, Sir" and Perkins would have passed up the steps into the long high room of the museum with quickening pulse as he scanned its crowded floor. Flooded with memories we may leave Jacob Perkins, in the midst of these objects of science and engineering, many of his own creation and the fruits of his long life of creative effort.

No organization is complete without its official publication so in connection with the museum Perkins decided to promote such a journal. This was called *The Magazine of Popular Science and Journal of the Useful Arts* and its address appears to have been the Lowther Arcade. It was issued under the direction of the Society for the Illustration and Encouragement of Practical Science (lengthy and profound titles were the order of that day). This publication first appeared in 1836 and was almost wholly inspired by Perkins' own views. His patent boilers and his theories on steam were much in evidence in its pages, this to such an extent that he received severe criticism in the pages of the *Mechanic's Magazine*. But by 1837 the popularity of the new magazine must have waned for there is no record that it appeared for more than two years.[193]

We have now reached the year of 1836 and in this year Perkins applied for his last three patents. The most important of these was that of April 12th which described a method of raising steam through the medium of hermetically closed water tubes. This patent also included a ball and socket joint for single acting cylinders and a spark catcher for locomotive engines. On Plate XXXVII is shown the drawing from the patent specification and also in the text a sectional drawing showing the assembly of the boiler, wheels and cylinder. Of this latter part, Perkins said in his specification:

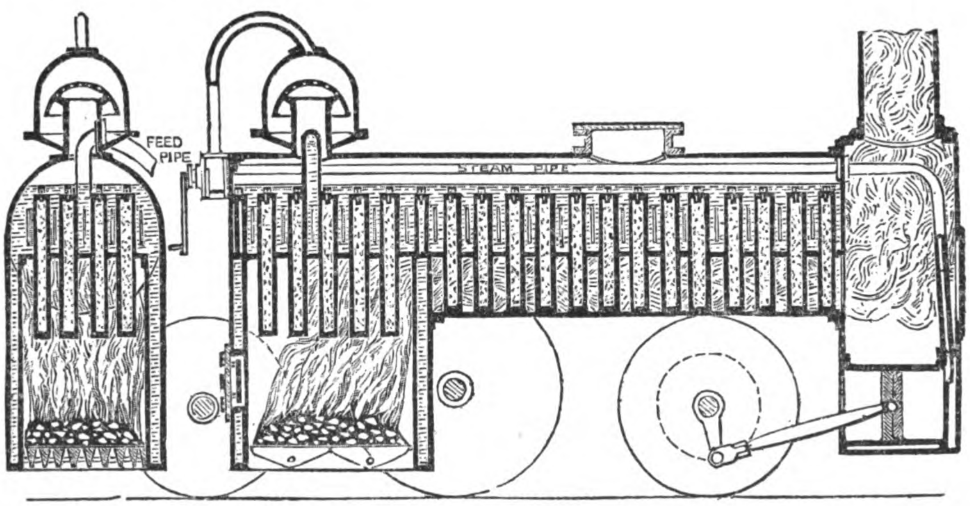
> First, of the improvements in steam engines.—Figure 1 shews a section of a steam cylinder intended for locomotive purposes, and the improvement consists in applying the connecting rod directly to the piston by a ball and socket joint, as is clearly shewn at *a*, the other end of the connecting rod being connected with the crank on the main shaft. Now, I am aware that in double-acting engines there have been somewhat similar means resorted to, but in such cases it has been necessary to have recourse to sliding stuffing boxes, or to tubes which pass through stuffing boxes, large enough to allow of the movement of the connecting rod; but by constructing single-stroke engines in this manner, the steam acting only against one side of the piston, no cover or stuffing box is necessary to the other end of the cylinder, and according to the arrangement shewn there only requires the bar *b*, against which the spindle of the valve in the piston comes, in order to open the same for the passage of the steam into the atmosphere at the end of the stroke; and I particularly recommend that high pressure steam should be employed and used expansively, say two hundred pounds to the square inch, and cut off at about one-eighth of the stroke, and expand down to atmospheric pressure.

For a locomotive there is obviously something sadly deficient in this proposal of Perkins, to use only single acting cylinders on a type of engine which required that one great essential, the necessity of starting from rest. As implied, but not mentioned, it would have required four cylinders with four cranks set at angles of 45 degrees from each other to provide the same turning effect which could be obtained by using two double acting cylinders with two cranks, each of which was set at 90 degrees, which is the usual method on locomotives the world over. The method of releasing the steam for the return stroke of the piston would have been most inconvenient and the engine driver would have been blinded by the vapor billowing back into his face. Perkins so often defeated his theoretical reasoning by his total lack of understanding of the mechanical demands in-

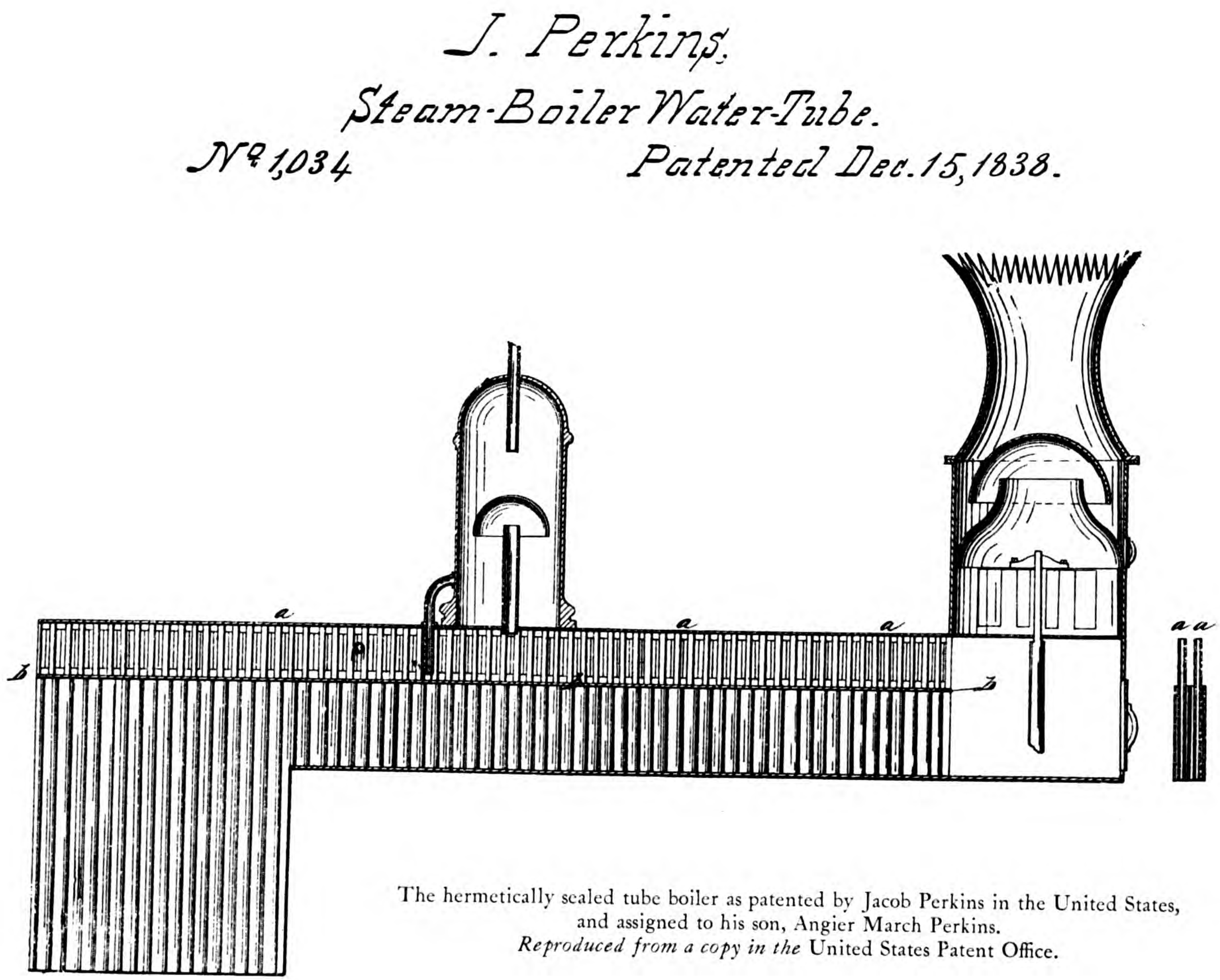
[193] We are informed by the British Museum that no copies of this publication can now be found.

volved. Inventing alone is not enough without a definite speculation of how the theory can be worked out. To continue Perkins' specification, he then described his boiler:

My second improvement is shewn at Figure 2. It consists of generating steam through the medium of certain closed tubes containing confined and surcharged steam. The boiler (which is shewn as applied to the purpose of a locomotive engine boiler) consists of a series of tubes, the one part of each tube projecting downwards into the fire or flue, the other extending above the bottom of the boiler, and the tubes are consequently surrounded by the water in the boiler. The tubes are hermetically closed to prevent the escape of steam. By this arrangement important results will be obtained; there will be no incrustation of the interior of the tubes, and the heat from the furnace will be quickly transmitted upwards; that the outer surfaces of the tubes will not be liable to scaleage or oxidation, which will of course tend much to preserve the boilers so constructed. These tubes are affixed in the bottom of the boiler by passing through holes formed therein, and I prefer that the joints should be made by spreading over, by hammering the parts *c*, Figures 3 and 4, which shews tubes separately; Figure 3 being those which go on the outside and are intended to touch, in order to prevent the passage of the smoke and vapours; and Figure 4, those which are applied to the other part of the bottom of the boiler, by which means the smoke and vapour pass freely between them and thence to the chimney. These tubes are each to have a small quantity of water depending on the degree of pressure required to the engine; and in order to the working of this construction of boiler to the greatest advantage, I recommend that the density of the steam in the tubes should be somewhat more than that intended to be produced in the boilers; and for steam and other boilers under atmospheric pressure, then the quantity of water to be applied in each tube is to be about one one thousand eight hundredth part of the capacity of the tube; for a pressure of two atmospheres, two one thousand eight hundredth parts; for three atmospheres, three one thousand eight hundredth parts, and so on, for greater or less degrees of pressure; by which means the tubes will when the boiler is at work be pervaded with steam, and any additional heat applied thereto will rise quickly to the upper parts of the tubes, and be given off to the surrounding water contained in the boiler; for steam already saturated with heat requires no more to keep the atoms of water in their expanded state, consequently becomes a most useful means of transmitting heat from the furnace to the water in the boiler. I would remark, that although I have recommended water to be put into the closed tubes, I am aware that vapours generated from other fluids will answer the purpose, and as the fluid in such tubes are not evaporated, no loss will take place; I do not, therefore, confine myself to the use of water, though I believe it to be the cheapest material.



Conjectual assembly of Perkins' locomotive of 1836.
From Burgh's *Treatise on Boilers.*



The hermetically sealed tube boiler as patented by Jacob Perkins in the United States, and assigned to his son, Angier March Perkins.
Reproduced from a copy in the United States Patent Office.

The principle of generating steam in boilers by this indirect method of transferring the heat of the furnace into the boiler water by superheated steam, has proved in practice very successful and was developed along somewhat different lines later by Angier March Perkins and will be described in its proper place. The rest of Perkins' specification refers to a spark catcher and methods of exhausting smoke by means of power driven fans, thereby dispensing entirely with the regular chimney draught.

It will be noted in the drawing at fig. 2 that the design of the spark catcher is repeated in the dome or chamber on the rear end of the boiler and is intended to separate the water from the steam. This form of spark arrester almost without variation had already been applied to locomotive chimneys in America in 1833 by Isaac Dripps a railroad engineer of New Jersey.

Figure 2, represents the improved construction of a flue or chimney for locomotive steam engines. *e* is an inverted portion of a sphere, in order to deflect any cinders or sparks into the outer casing *f*, from which they may be removed by a door (not shewn in the Drawing), whilst the smoke and vapours pass freely off; and I do claim the application of such arrangement of apparatus to the flues or chimneys of locomotive steam engines. And in order to improve the working of steam engine boilers for marine purposes, and at the same time to dispence with the vertical chimney now employed, I construct the same horizontally, and prefer it to be below the deck, such flue being composed of a series of flat chambers, through which the atmospheric air comes, in order to supply the fuel in the furnace and keep up combustion, the smoke and vapours from the furnace passing in the opposite direction, and in the spaces between those through which atmospheric air passes. To the end of such flue, and in connection only with the spaces through which the smoke and vapours pass, is formed a chamber, having two eduction pipes, one into each paddle box of the steam boat; and in such chamber is applied a rotatory exhauster or fan, such as are now becoming commonly employed for forcing air into furnaces for smelting iron, rotatory motion being communicated thereto by the engines. The smoke and vapours rush into the chamber, and are forced out therefrom by the exhauster (now acting as a blower) into the paddle boxes, where by the working of the paddle wheels the same is condensed or so washed as to offer no annoyance to the passengers; and as the smoke and vapours from the furnace rush towards the exhauster, streams of atmospheric air are travelling in the opposite direction and becoming heated, and thus is more suitable for supporting combustion. Now, I would have it understood that I am aware that tubes have been before placed in flues for heating the atmospheric air previously to coming into the furnace; I do not therefore claim the same, but only when combined with a rotatory blower, and applied to marine steam engine boilers, whereby the vertical flue or chimney is dispensed with, as above described.

No doubt Perkins along with many others who traveled by the Thames River steamboats, which had recently come into public favor, found that the constant lowering of the funnels to make the passage under the bridges produced an unwelcome change of countenance due to the billowing smoke which poured out of the aperture left temporarily vacant in the deck (Plate XXXIX). It was probably after such repeated happenings to himself that prompted Perkins to propound this ingenious solution to benefit a vexed public. By this period the river steamer had already made serious inroads into the watermen's business. In 1836 there were 2,085 licensed wherrys below and 643 above London Bridge as against 12,000 at the turn of the 19th century. The *Penny Magazine* of 1837, referring to passenger travel on the Thames, says: "Until lately the watermen thought that even if the river below the bridges was taken from them, still they were secure of it from London up to Windsor. But the restless 'demon of the waters' chases them up the river. Little

steamers are now seen in nautical phraseology, 'shooting' the arches and wreathing the bridges in smoke." Perkins, while realizing perhaps the necessity for his smoke condensing device for steamboats, did not consider sufficiently the unstable platform which supports the propelling machinery. The dispensing with a vertical smokestack or funnel on steamboats is a matter which has occasionally been advocated but never successfully applied because of the danger of swamping through the hull apertures when the vessel rolls.

The foregoing patent of April 12th was shortly afterwards followed by another dated June 13th and this was for "Apparatus for Cooking," but as no specification was enrolled by Perkins for this, the nature and particular use of this invention is in doubt. However, in an early patent file under the name of Amos Kendall of Ipswich, Massachusetts, has been found the record that he patented a "cooking stove" on April 28, 1836, which invention had been assigned to him by J. Perkins. In the absence of further details, it may be supposed that the reason Perkins did not enroll any specifications to his provisional application was due to this assignment which would have rendered any further proceedings by Perkins unnecessary.

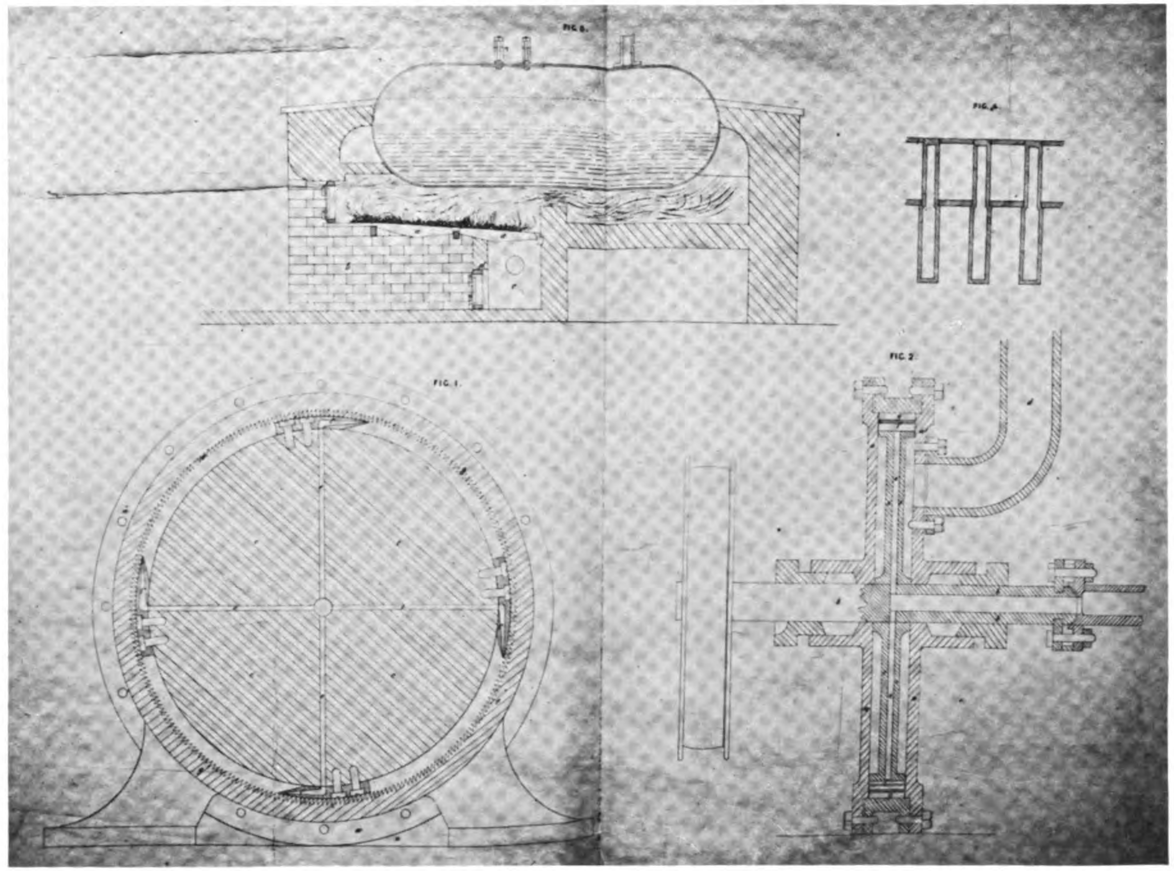
Jacob Perkins' final British patent was taken out on December 3, 1836, and was for "certain improvements in Steam Engines, Furnaces, and Boilers, parts of which improvements are applicable to other purposes." After the manner of drafting patents in those days, this covers, as previously, several separate inventions, a sometimes fatal money saver, for, if by chance, one of the enrolled specifications was contested at law for infringement and the inventor lost, he also lost all the others specified in the particular patent. In this final patent of Perkins, he first described a steam wheel or turbine which could be used equally well with water pressure. This engine is shown on Plate XXXIX, figs. 1 and 2. Here again the creasing of the drawing has caused some distortion, but the rarity of some of the Perkins patent specifications has given little choice to the authors in the matter of reproduction.[194] This turbine was a neat little piece of work and was far better suited to Perkins' ultra-high pressures than the reciprocating type which he had clung to so persistently. The design of this machine needs little explanation; the steam enters by the hollow shaft b.b. and passes through the four passages in the wheel to the jets, then the steam impinges on a serrated ring. This little turbine engine was designed by Perkins several years prior to his patent and was one of the thrilling exhibits shown to the curious public at the Adelaide Galleries. In the *Mechanics' Magazine and Register of Inventions* of November, 1833, is to be found the purpose to which this steam wheel was applied:

COMBUSTION OF THE HARDEST STEEL

A disc of soft iron, to which motion is given by a steam engine, attached to the boiler of the steam gun, is turned with a velocity of 5400 revolutions in a minute; and by placing a file, or other piece of the highest tempered steel, in contact with the periphery of the disc, the friction caused by the soft iron destroys or cuts the steel, producing thereby a brilliant and beautiful combustion.

The second part of this patent refers to furnaces, and is indicated at fig. 3. This was a method to augment the air which was admitted naturally through the fire bars. At b. is the

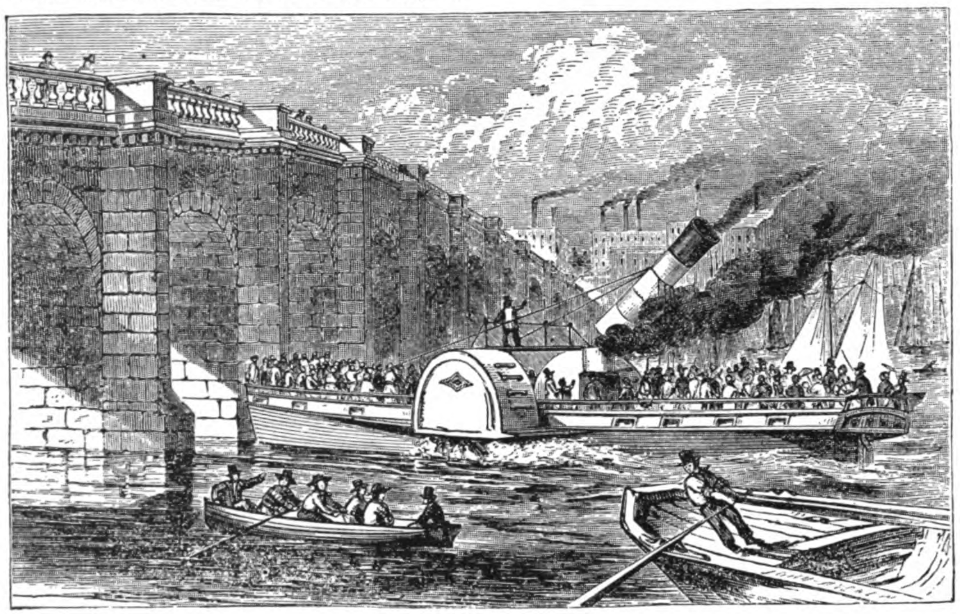
[194] The majority of Perkins' British patent specifications are definitely out of print and copies could only in a few instances be obtained from the British Patent Office. However, a bound volume containing some duplicate copies in the files of the United States Patent Office library was made available to the authors. Unfortunately the method of binding these prevented a clear and satisfactory reproduction of the drawings.



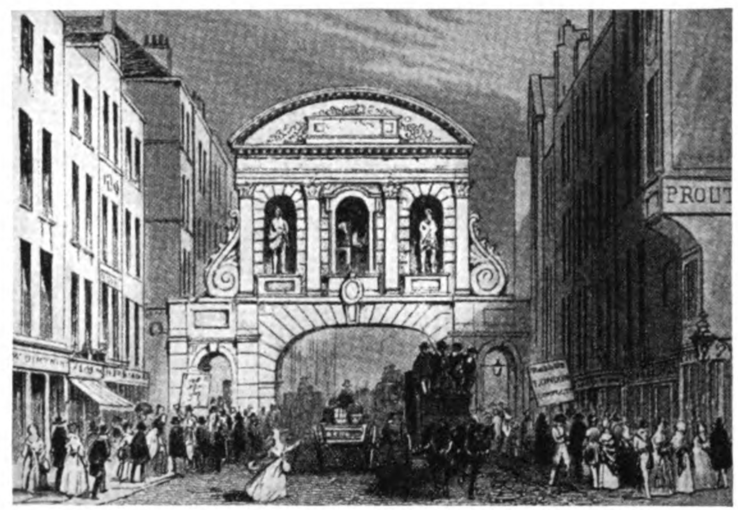
Perkins' Turbine Steam Engine of 1836 and other Inventions.

From a copy of the specifications in the United States Patent Office.

Figs. 1 and 2—Sectional views of the rotary engine. Fig. 3—A Smoke consuming furnace. Fig. 4—Improvement to the hermetically sealed boiler tube. All the foregoing are described in the text.



"Shooting" Blackfriars Bridge. Thames steamboat and wherry, typical of the river traffic which Perkins knew in the 1840's.



Temple Bar, looking towards Fleet Street with Shillibeer's omnibus in the foreground.

ordinary ashpit, c. is the ashpit under pressure from a blower or fan, d. is the partition which divides these two ashpits. By intensifying the combustion at the back of the furnace, smoke and unburnt gases would be the better consumed.

The third section of the patent amplified the patent of April 12th by saying in effect that the hermetically sealed tubes could be extended to the top of the boiler shell and riveted securely to it, thus adding to the strength of the boiler. At fig. 4 is shown this addition.

The hermetically sealed boiler tube was patented in the United States December 15, 1838, by Jacob Perkins and was then assigned by him to Angier March Perkins as of that date. One of the witnesses to this specification was William Heath, a son of Charles Heath. William Heath later practiced as an engineer while his brother, Frederick, preferred to follow their father's profession. The drawing from the American patent is shown on Plate XXXVIII and it will be noticed that an exhausting fan is indicated in the smokebox, the spindle of which was intended to pass down to bevel gearing and be driven by the front axle of the locomotive. The only claim set forth in this patent was for the closed tubes and their thermal conductivity but it is stated further that "as the heat from the furnace will be quickly transmitted upward, the outer surfaces of the tubes will not be liable to scaleage or oxidation, which will of course tend much to preserve the boiler so constructed." True, perhaps, but it must also be evident that any form of tube closed on the end which hangs down into the heart of the furnace, containing dead water, i.e., that which does not circulate, will quickly revert to the equivalent of a dry tube as the caloric of the confined steam intensifies. If the temperature of the tube reached a red heat, oxidation and scaling on the outside must take place until the tube becomes too thin to withstand the internal pressure of the confined steam.

However, the correctness of Perkins' theories on the transfer of heat was amply proved by Charles Wye Williams in a demonstration before the Liverpool Polytechnic Society in 1841. On this occasion a small boiler with an internal flue was prepared with a large number of half inch round iron pins which projected down into the flue and for an equal length up into the water. These pins were termed "double conductors" and it was found that this simple addition increased the evaporation by 50 per cent over a similar boiler which was not provided with these conducting pins. A trial of this principle was made on a full scale by John Dewrance, the locomotive superintendent of the Liverpool and Manchester Railway, on a stationary engine boiler used at one of the inclined planes. According to the *Railway Magazine* of October 30, 1841, with "only a 105 pins driven into the boiler, the steam, which could not before be kept up, was now abundant." The absence of any record of Perkins' sealed tubes having been used at this time makes it impossible to compare their thermal efficiency with the simple pin conductors invented by Williams, but the same objection can be raised that the pins also would have had a tendency to deteriorate rapidly if applied in the immediate area of the furnace.

The Britannia Nail Works, which had originally been founded by Joseph C. Dyer in Birmingham, in 1811 with Jacob Perkins' patent nail machines, continued to flourish through the years. At this period, it was under the ownership of Winkfield, Church and Blyth. The London agent for this firm, in 1835, was Charles Houghton of 44, Farringdon Street, Snow Hill, and from his business prospectus can be mentioned some of the nails with queer sounding names, which were made at that time. These included "clasp,"

"clouts," "shoe bills," "Canada rose," and "Flemish tacks." In 1839 the Britannia Nail Works passed from a purely private ownership to company management, under the title of the "Chunk Nail Company, Britannia Works," and continued until 1867. The rapid improvements to nailmaking machinery which had taken place during Perkins' life had long rendered his machine obsolete, but nevertheless it was to Dyer's business acumen and Perkins' ingenuity that the introduction of the machine-made nail into England was so largely due.

On October 5, 1837, Hannah Greenleaf Perkins, Perkins' wife of many years, died at Newburyport, Massachusetts. She apparently returned to her native place sometime in 1836, though the exact date is not known. In 1839, on Tuesday, April 2nd, died Jacob Perkins' loyal brother, Abraham, at his old home on Fruit Street in Newburyport. A notice of his death in the *Daily Herald* of Wednesday, April 3, 1839, reads:

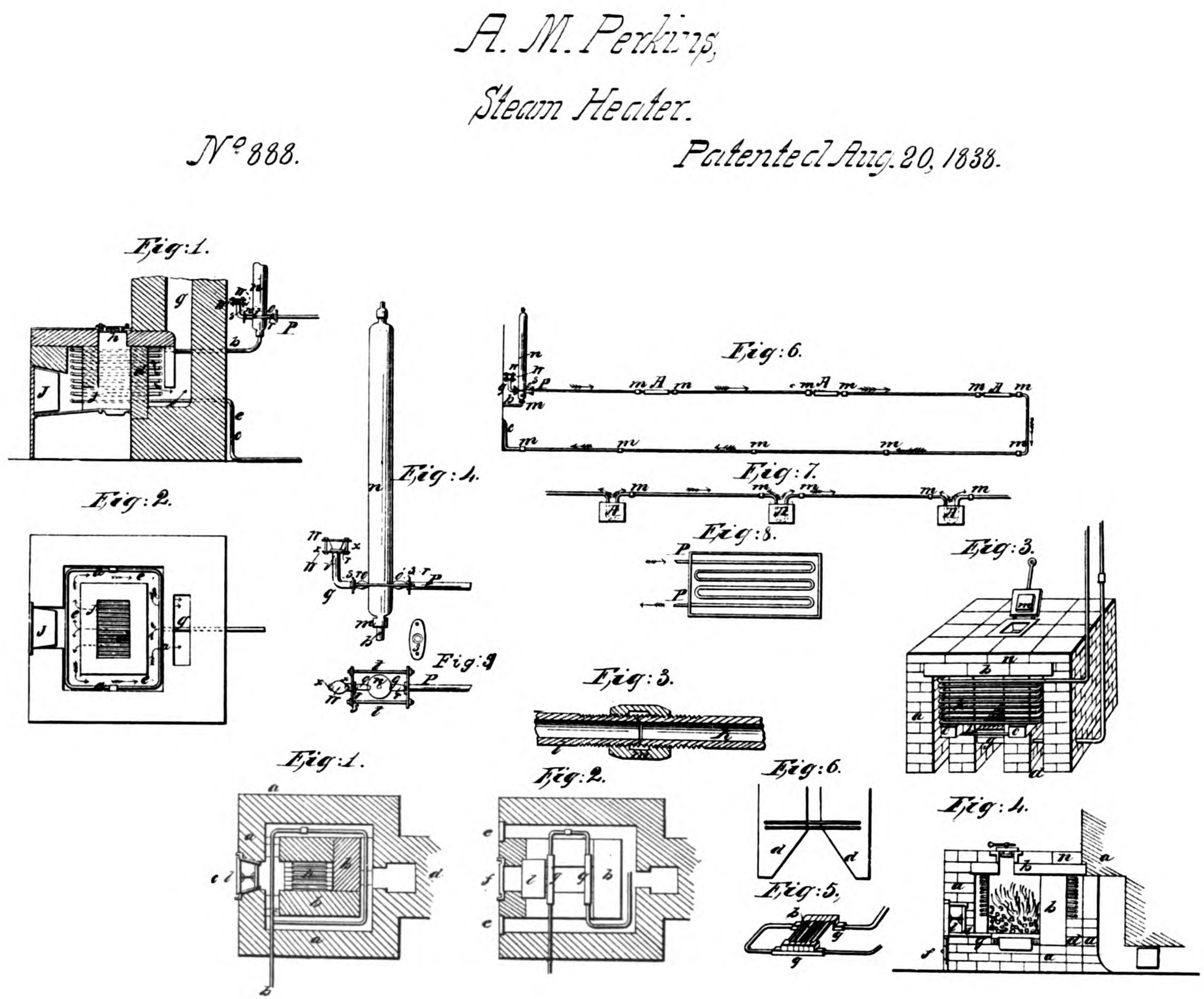
> In this town on Tuesday morning Maj. Abraham Perkins aged 71 years. Funeral Thursday afternoon at 3 o'clock—friends and relatives are invited to attend without further invitation.

Abraham Perkins had been a Major in the Massachusetts Militia, and died well off by the standards of those times. His house on Fruit Street was valued in the inventory of his tangible estate at $3,000. His will was somewhat involved, the contents of his house being willed room by room to his many legatees but among these there is no mention of his brother Jacob. Of Perkins' reactions to his brother's death we have no record. He had retired entirely from business two years before this and the name of Perkins and Company, Engineers, no longer appeared in the London directory. On February 7, 1837, Perkins at one of his now rare appearances at the meetings of the Institution of Civil Engineers, read a paper on *Locomotive Engines and the Means of Supplying them with Steam,* a dissertation on his hermetically sealed boiler tubes.

It is very difficult to know to what extent Jacob Perkins actually tried out the ideas he put forward with such assurance. It would seem most logical that before one went to the expense and trouble of a patent,[195] one would be very sure that the idea was sound and practical, yet in reading through many of Perkins' specifications, the feeling is unavoidable that the practice was subservient to the theory. This particularly appears to have been the case in Perkins' later inventions connected with steam boilers.

After Jacob Perkins' retirement from active business, about 1836, Angier Perkins occupied all of the Francis Street works and used them entirely for fabricating the parts

[195] By comparison with other countries, British patents were very expensive to obtain, £120 was about the minimum and the cost could be far greater if the specification was involved or required complicated drawings to describe the invention. The term of patent protection in England and America was fourteen years with the right to renew for a further term. In France and the Netherlands, a patent ran for five, ten or fifteen years at the option of the patentee who paid accordingly. The cost of an American patent was only $30 and protection could be claimed by the patentee only if he was the original inventor, while in England and France a patent could be obtained by anyone who first made an invention public irrespective of whether he had conceived it or pirated it. The first patent privileges given in England were for nobility in 1344 and the first grant for letters patent pertaining to manufacturing and other arts, was in 1623. Various amendments to the patent laws have been made, notably in 1835 and again in 1852. The patent law of the United States was first set up in 1790, termed "An Act to Promote the Progress of the Useful Arts." This was revised in 1793 and again in 1800. In many cases, both in England and in America, models of the invention were required to be deposited along with the specifications but this practice was generally discontinued by all countries in the middle of the nineteenth century through lack of space to house the ever-increasing exhibits.



Angier March Perkins' United States patent for heating buildings. Half of this patent was assigned to Merritt Moore Robinson, of Louisiana, his lawyer and agent. *Reproduced from a copy in the* United States Patent Office.

of his hot water heating plants, which he had by now successfully introduced into several branches of industry. Wishing to expand into further fields with commercial possibilities, Angier Perkins on August 20, 1838, filed in the United States a patent described as a *Mode of Heating Buildings and Evaporating Fluids*. In three pages of carefully worded print, Angier Perkins described in great detail his invention. The principal part of this was the heater which was built of brick about four feet six inches square and which contained a coil of one-inch diameter pipe as shown at fig. 3 on the specification drawing. (Plate XL.) The furnace g. was supplied through the hopper on the top with coke or anthracite coal and the combustion from the grate passed up through the coils into the chimney. The heater coil did not come into direct contact with the fire and this coil and the rest of the system were entirely filled with water which circulated as it cooled back to the furnace, and was reheated. The radiating pipes for heating the building are shown at fig. 6 and at fig. 4 is given in detail the expansion tank to prevent the pipes from bursting as the water increases in bulk by heating. At fig. 7 is shown an arrangement for dispensing with the charcoal stove used by copper plate and other printers, for the purpose of heating the engraved plates prior to taking impressions. As indicated at fig. 7, a U bend containing the superheated water was immersed in a rectangular bath of molten lead or other easily fused metal which by conductivity transmitted the right amount of heat to the copper engraving plate. By the old way, the charcoal stoves were either too hot or too cold and the consistency of the printing ink was never twice alike. A method of boiling syrup in the refining of sugar is shown at fig. 8, the tank containing the liquor was heated by the hot water coil PP. At fig. 3 is shown the screw couplings used for connecting up the length of pipe by means of a right- and left-hand threaded socket.

On December 16, 1839, Angier March Perkins patented a steam generator which, while it contained the same general principles of indirect heating featured by his father, also contained the element of enduring construction. On Plate XLI is a sectional drawing of this boiler and the system works as follows: the heat from the furnace G is made to pass downwards through the heating coils E and so through the damper to the chimney. The water, after having been highly heated, in passing through the coils E ascends into the boiler by the pipe F and circulates through the gridiron of pipes FF and its heat is transmitted to the water contained in the steam boiler proper. The water then returns back to the coil E for reheating. The pipe and loaded valve K are used to relieve the expansion as the water heats, and supply any deficiency in the coils. This boiler, as it will be surmised from its construction, was intended for only low pressures. It is stated that the boiler was tested to 100 pounds and the working pressure a maximum of 41 pounds. The total cubical contents of the steam boiler was 52¼ cubic feet (steam 32¼ and water 20).

The amount of piping in the hot-water coils was 772 feet of ½-inch bore and as the tubes were always full, there was but little chance of deterioration in the furnace. In principle, this boiler followed closely on the lines of Jacob Perkins' coil generator of 1823, except that the superheated water in the furnace coils was used only as a medium for transmitting the heat of the fire into the boiler water, instead of allowing it to flash into steam and using it immediately in the engine.

This type of boiler was later redesigned as a horizontal tube injection boiler and was repatented on December 6, 1855, by Angier March Perkins. In this later type of boiler the hot-water coils were heated as before, but they afterward passed through the center

of a series of larger pipes which encased them. Water was then injected into the annular spaces thus formed by the two tubes and as the water passed and repassed upwards through these jackets, steam was generated. By this means of construction, safety and very high steam pressures could be obtained. The work of both Angier March Perkins and Loftus Perkins in this field of high pressure steam would make a long and interesting story in itself but it is beyond the scope of this work. It is therefore considered best to touch only on that portion of Angier March Perkins' work that is contemporary to the life of Jacob Perkins.

It is here necessary to consider in some detail an event which vitally affected the whole course of worldly affairs. This was the introduction by Great Britain of the first penny postage stamp service, and the part played therein by Jacob Perkins' process of steel engraving. To lead up to this, some general facts bearing upon the situation may be recapitulated. Up to December 5, 1839, the rates of postage varied according to the distance of transmittal. Thereafter, for the brief period of one month, the Government as an experiment tried out a flat rate of four pence a letter. It had already been decided earlier in the year to reorganize the postal system and on September 14, 1839, Rowland Hill[196] was appointed to assist the Government in its arrangements for organizing a scheme to place the penny postage in operation. It was suggested at the time that for a matter so important to the general public, a competitive prize should be offered for the best suggestion as to how the whole scheme should be carried out.

In the *Times* of September 6, 1839, it was made known that £200 and £100 would be awarded for the first and second best proposals. The Treasury competition was not decided until December 26th, by which time over 2,600 communications bearing on the subject had been received. In consultation with Rowland Hill, the Government decided to divide the award between four of the entrants whose plans seemed most feasible. These persons were Messrs. Bogardus and Coffin, Benjamin Cheverton, Henry Cole and Charles Whiting, who each received £100 by way of compensation for their ideas as submitted, and from these winners, Henry Cole was appointed to assist Rowland Hill in his work at the Treasury Department. Cole was deputed to interview Messrs. Perkins, Bacon and Petch with a view to having this firm make the master dies and print off the many thousands of sheets of adhesive stamps necessary to put the penny post into operation. After an interview, Messrs. Perkins, Bacon and Petch wrote Cole as follows:[197]

69, Fleet Street, London,
3 December 1839.

Sir,

We have given the subject you mentioned yesterday afternoon all the attention the time would allow, and beg to say as the result that:—

We could engrave steel dies of the size you mention, containing work of any conceivable value

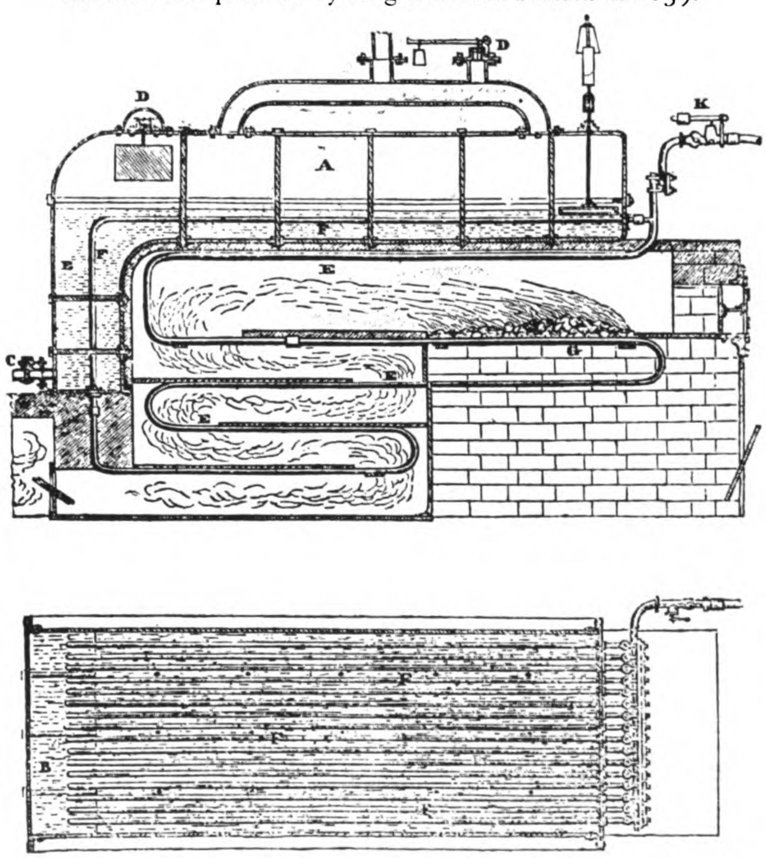
---

[196] Sir Rowland Hill at this period had not received his knighthood. He was born at Kidderminster, Worcestershire, in 1795 and commenced life as a teacher and educator and later held a government post connected with the colonization of South Australia. He published in 1837 a pamphlet *Post Office Reforms*, dealing with the need of uniform postage rates. A national testimonial was presented to Hill on June 17, 1846, by an appreciative public and on the 30th of November the same year, he was appointed secretary to the Postmaster General, in which position he remained until 1854. After this he was chief secretary to the Post Office until 1864. In 1860 he was created K.C.B. Sir Rowland Hill died in 1879 and was buried in Westminster Abbey.
[197] *A History of the Adhesive Stamps of the British Isles*, by Hastings E. Wright and A. B. Creeke. London, 1899.

Angier March Perkins.

From a silhouette in the possession of Mrs. Edward S. Brown, Newburyport. Believed to have been cut by the celebrated French silhouettist, Augustin Edouart.

Steam Boiler patented by Angier March Perkins in 1839.



A—The low pressure boiler. EE—The heating coils. FF—The radiating coils. G—The furnace. K—The water supply. DD—The safety valves. The action of this boiler is described in the text. Reproduced from the *Mechanic's Magazine*.

as to cost and quality, transfer them to any number of plates that could possibly be wanted, and print them in any numbers per day, at a charge of eight pence per thousand stamps, exclusive of paper, which, we understand would be supplied us; and, assuming that the numbers wanted would be very large, we have only named a fair price for the printing, and have considered the plates and dies, which ought to be very costly in the first instance, as given in without charge. You are probably aware that, having prepared the original die, we could insure perfect facsimiles of it for a century.

Our charge would not exceed what we have named above, nor be less than six pence per thousand; but what relative position it would take between these two extremes, would depend upon the exact size of the stamp, and the number which the paper would allow us to put upon one plate.

We could prepare everything so as to commence printing in a month. Our present belief is that we could print 41,600 labels per day, or double that number in a day and night, from each press employed upon the work.

We are, Sir, very respectfully,
Your humble servants,
Perkins Bacon & Petch.

Henry Cole, Esq.

It was also planned by the Government to have decorative envelopes and covers printed, in addition to the stamps, by Messrs. Clowes and Sons of Blackfriars, from the design of William Mulready, the celebrated Irish painter.[198] On March 18, 1840, in a letter from Mr. H. L. Wickham to Rowland Hill, on the subject of the cost of the new stamps, it was stated that Perkins, Bacon and Petch were to receive 7½ pence per thousand for the stamps, which price was to include gumming the sheets, making the plates, and every other charge connected with the transaction except the paper, this latter was to be supplied watermarked by the Government. This first contract was made for one year under these terms. The engraving on steel of the Queen's head [199] was entrusted to Charles Heath, but the work was actually executed by his son, Frederick Heath,[200] and when finished, the engraved die was multiplied as it was transferred onto eleven steel plates, prepared and hardened by the process invented by Jacob Perkins many years previously.

To obtain some idea of the feverish activity which animated the Fleet Street plant during the printing of the first penny postage stamps, we may quote from an able work on this subject: [201]

On the 14th April, 1840, Mr. Rowland Hill visited the works of Messrs Perkins, Bacon & Petch, to ascertain what progress they were making with the plates for printing this value. One plate was then just completed, and a second one was to be ready on the 20th. Two presses were also ready; a third was to be finished by the 20th, a fourth by the 27th, and, in addition, two more were in progress. The printers undertook to deliver 200,000 stamps by the 20th April, and to continue the supply at the

198 William Mulready, 1786-1863. Born at Ennis, Ireland. As a child he was brought to London in 1791. His early work was largely that of illustrating books and he was considered a consistently good artist. He was elected to the Royal Academy in 1816. Mulready's design for the envelopes, which bear his name, was emblematical of Britannia sending winged messages to all parts of the globe. A caricature of the design is to be found in *Punch* of that current year, by John Leech.

199 Edward Henry Corbould, the painter, drew the design for the Queen's head and received £12 from Perkins, Bacon and Petch for this artistic work. Corbould was married to one of Charles Heath's daughters.

200 Frederick Augustus Heath, a son of Charles Heath, was born in 1810 and died May 7, 1878. All the early writers on postal history credit Charles Heath with engraving the Queen's head but later evidence based on an entry in the books of Perkins, Bacon and Petch more than indicate that the work was actually done by Frederick Heath. As well as the first penny stamps, Frederick Heath engraved the five shilling coin stamp of New South Wales issued in 1861 and also the small half penny red stamp of Great Britain in 1870.

201 *A History of the Adhesive Stamps of the British Isles*. Wright and Creeke, 1899.

rate of 240,000 stamps per day afterwards, to be further increased when they got more than two presses to work, the increase to be at the rate of 120,000 stamps per day for each additional press. To effect this rate of production, they explained that it would be necessary to keep the plates at press day and night. Mr. Rowland Hill was informed at the same time that each new plate would occupy from ten to twelve days in construction.

The Fleet Street establishment was of considerable capacity, according to Thomas Gill, in 1839 there were nearly forty "improved rolling-presses" continuously employed by Perkins, Bacon and Petch at that time.

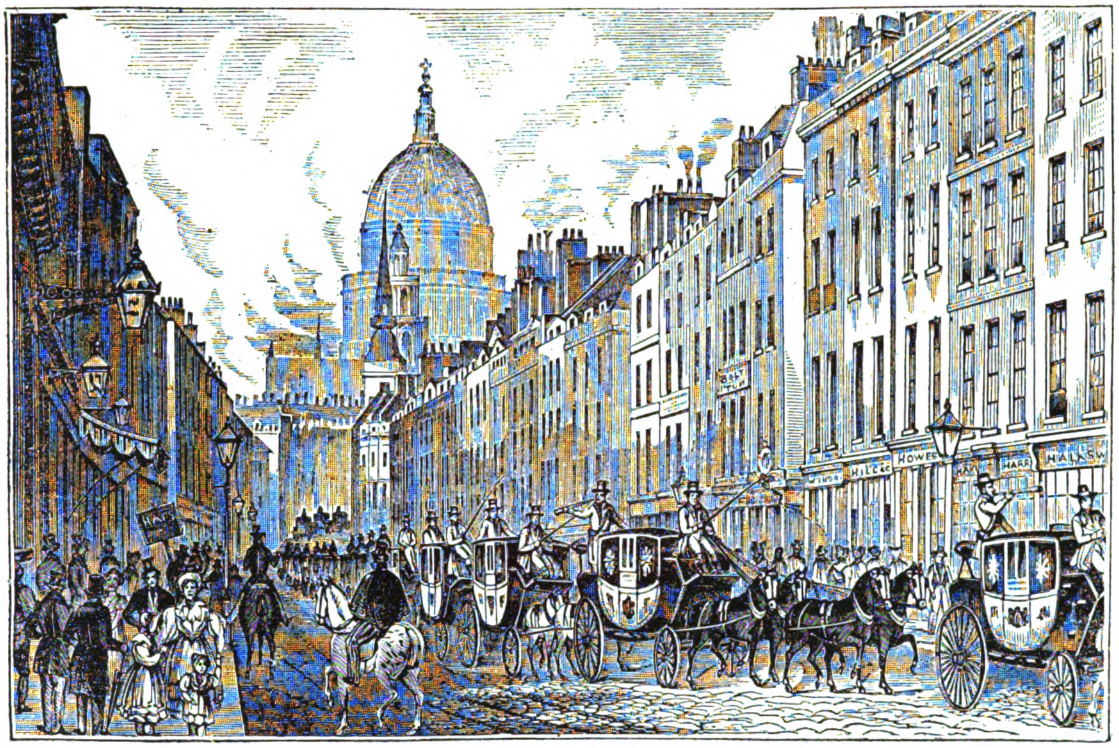
The first prints of the penny black line engraved stamp was issued May 6, 1840, and was followed shortly afterward by the two penny blue. In 1841 the black penny stamp was discontinued and the penny stamp appeared in various shades of red, orange and

An enlargement from the proof die used for the first penny postage stamps of Great Britain 1840. This die was in use until 1855 when it was re-engraved by William Humphrys as Die II. In the proof specimen shown, the corners are not yet completed with the Maltese cross and plate letters. From Dendy Marshall's *The British Post Office from its beginnings to end of 1925.*

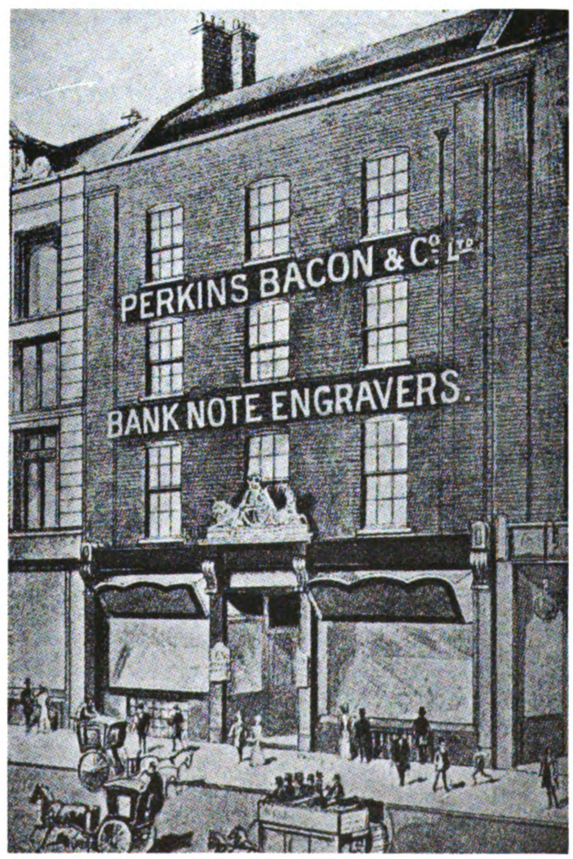
brown.[202] From the correspondence of Perkins, Bacon and Petch at this time,[203] it appears that many experiments were made with inks which could not be eradicated and inks that would dissolve before the postmark, in the event of this kind of forgery being attempted which would make the stamp appear unused. Also there were heated discussions between the members of the firm as to colors and shades, such as whether to use prussiate of potash in fugitive ink, and whether to print with oil or without, the texture of the gum for the adhesive backs and the number of first impressions, and so on in endless detail throughout the whole of 1840. In the settling of all these matters, Jacob Perkins must have had his say in the discussions, but his valuable advice in the one subject which he really understood is not especially recorded and this important work, it may be said, was Jacob Perkins' swan song of worldly endeavor.

---

[202] The first one penny black varied considerably in color tone. The intense black is from a new plate while a gray black indicates a worn plate. The stamp paper, watermarked with a crown, was supplied by the Mint. Unused, these stamps are now priced at $20 and the twopenny blue is valued at $45. On the first sheets issued, the stamps had to be cut as required but later they were perforated. The machine used by Perkins, Bacon and Company was a comb which punched out one line at a time and was 14 and 16 perforation gauge.
[203] *The Line Engraved Postage Stamps of Great Britain Printed by Perkins, Bacon and Company*, by Edward Denny Bacon. 2 Vols. London, 1920. This work is a most complete history of the firm.



Fleet Street, about 1836, showing a procession of mail coaches. In the center, on the south side of the street, is the Bolt in Tun, a famous inn, first mentioned in a land grant in 1443. A few doors down, on the same side, was the engraving plant of Perkins, Bacon and Petch. From *The Penny Magazine*.



The Engraving Plant, at 69 Fleet Street, as it looked in the eighties. From *The Business World*.

The firm of Perkins, Bacon and Petch (until 1852) and in its later form, Perkins, Bacon and Company, continued to print the line engraved stamps of Great Britain and the colonies until 1879. By 1855 the surface printed stamp, the work of Messrs. De La Rue and Company of London, was first introduced and gradually displaced the stamps printed directly from engraved plates. Over twenty-two thousand million stamps for Great Britain and the colonies were printed during these years from Perkins' plates, a great tribute to this enduring system. Many of the classic stamps of the British Empire, including such intrinsic gems as the triangular Cape of Good Hope of 1853-1858, Ceylon 1857, and Queensland of 1860, were produced from Perkins' plates, though not always printed by the firm.

Up until the Act of 1844, private banks in England were allowed to print their own notes and a few of these, printed from Perkins' plates, have come under the authors' observation.[204] These include Norwich Crown Bank £1, Cranbrook Bank £10, Kendal Bank £1, Flintshire Bank £1, Oswestry Bank £1, with names engraved thereon—Croxon, Jones, Croxon and Company—and Dowlais Bank of Glamorganshire for the Dowlais Iron Works, £1.

In 1863 Joshua Butters Bacon died, the last link with the old days and Perkins, Bacon and Company became later a limited company in 1887. The premises at 69 Fleet Street were retained, however, until 1904 when the firm of Perkins, Bacon and Company Limited removed to a more modern plant in Bermondsey, at Southwark Bridge Buildings, under the direction of Mr. James Dunbar Heath, a grandson of Charles Heath, one of the founders of the firm, in 1819. We are informed that in 1935 the firm sold all their business interests to Messrs. W. W. Sprague and Company, of Bread Street Hill, E.C., but the business title is still used.

Early in 1842, on January 20th, died Jacob Perkins' eldest son, Ebenezer Greenleaf. He passed away in Newburyport following long years of invalidism. Jacob Perkins outlived all his family with the exception of his second son, Angier March, and three married daughters.

Shortly after 1843, Angier March Perkins moved to No. 18 Regent Square, a more imposing dwelling,[205] as befitted his increasing business prosperity. Here Jacob Perkins spent the last years of his life, his body slowed down by the infirmities of age, but his mind active and agile. One may imagine that he was able to enter into long discussions with his son on the current problems of steam power and its future development.[206] On

[204] Taylor Collection of the American Antiquarian Society.

[205] No. 18 Regent Square as it appears today is pretty much the same as when Jacob Perkins lived there. It is in a pleasant, peaceful, little backwater, not far from St. Pancras and on the edge of Bloomsbury. The house is tall and dignified with the plain exterior which prevailed in the late Georgian period. The house is on the southwest corner with its portico entrance (probably of a later date) on Compton Street. In Perkins' day the south side of the garden faced on Sidmouth Street and Compton Street did not extend beyond Hunter Street, as shown on our early map of London. The front of the house has eight windows which overlook the gardens of the square with its well-kept turf and beautiful old plane trees. Apparently there has never been any effort to mark the house with a tablet commemorating the fact that here Jacob Perkins, the engineer and inventor, lived and died though on almost every street in central London such markers are to be found.

[206] The possibilities of high pressure steam were developed by Angier March Perkins principally along the lines of heating, though a few of his patents concerned the steam engine, one of which was an injection boiler in 1855 and another was for improvements on high pressure engines and condensers in 1858. Some of his inventions did not fall into either category, such as one on improvements in railroad axles and boxes in 1851, and one for pumps in 1861, to mention only a few of his many patents. Angier March Perkins took his son

January 21, 1841, Angier Perkins had patented some further improvements in his methods of heating buildings, etc. It was found that the small diameter of wrought iron pipes limited the available radiating surface considerably and their enduring qualities were not too good. For heating hot houses, where lower temperatures and much moisture prevailed, the use of cast iron pipes of 3 to 4 inches diameter, was found more satisfactory. This alteration in the piping used called for a special socket joint and also a lateral sliding expansion joint to prevent the brittle cast iron from fracturing as it became heated. On March 16, 1843 Angier Perkins obtained another patent which was for manufacturing and smelting iron by blowing preheated steam and air into the cupola in place of the usual cold blast. At this period the battle between the upholders of the old method of employing cold air and the new order of ironmasters, who advocated the hot blast in manufacturing iron, was at its height. Robert Stephenson conducted, in 1846, a series of experiments on the breaking strength of cast iron made by these two methods and advocated the hot blast as being more suitable for bridge construction. Henry Hartop of Doncaster, published in the *Mining Journal* of August 6, 1842, a paper in which the superiority of the hot blast for cast iron pipe was cited. No doubt Angier Perkins' anxiety to obtain a better grade of iron for his growing business inspired this patent in 1843. The specification is brief and only the method of application was claimed.

An extension of the heating patent of 1831 was obtained by Angier Perkins on July 21, 1845, for a further period of 14 years and three more patents of a kindred nature were taken out later, one in 1851 for heating bakers' ovens by hot water, and two in 1864 for heating by means of coils of pipe, a construction which afforded a great saving of space.

It is stated [207] that Loftus Perkins, Angier Perkins' second son, entered his father's factory at a very early age, which seems to imply that he started there as an apprentice probably about 1848.

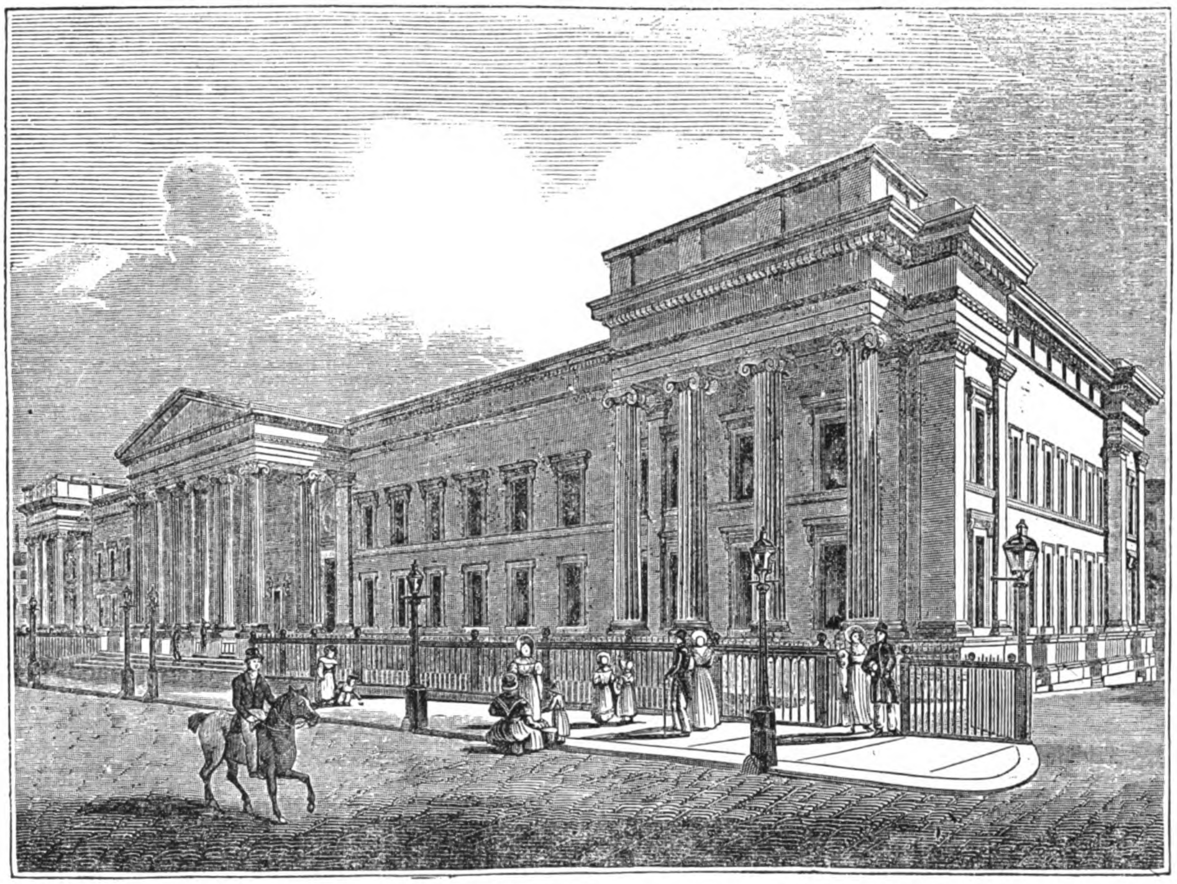
Of Angier's eldest son, Angier Greenleaf Perkins, there seems to be little known. He died at his home on Hornsey Street, Islington, on January 20, 1871, at the early age of 38. His death certificate indicates the cause of death as an organic disease of the stomach and gives his profession as that of an engineer.

By the end of the forties and before Jacob Perkins passed away, the Adelaide Gallery no longer drew the crowds of scientific and mechanically minded public and like so many serious and educational exhibitions, it began to slip down hill. Albert Smith, writing of this fact in his *London Life and Character* draws a racy but painful picture of the Gallery's last days, which it will be remembered was founded in 1832 by Jacob Perkins in an effort to bring the things he loved to a better popular understanding:

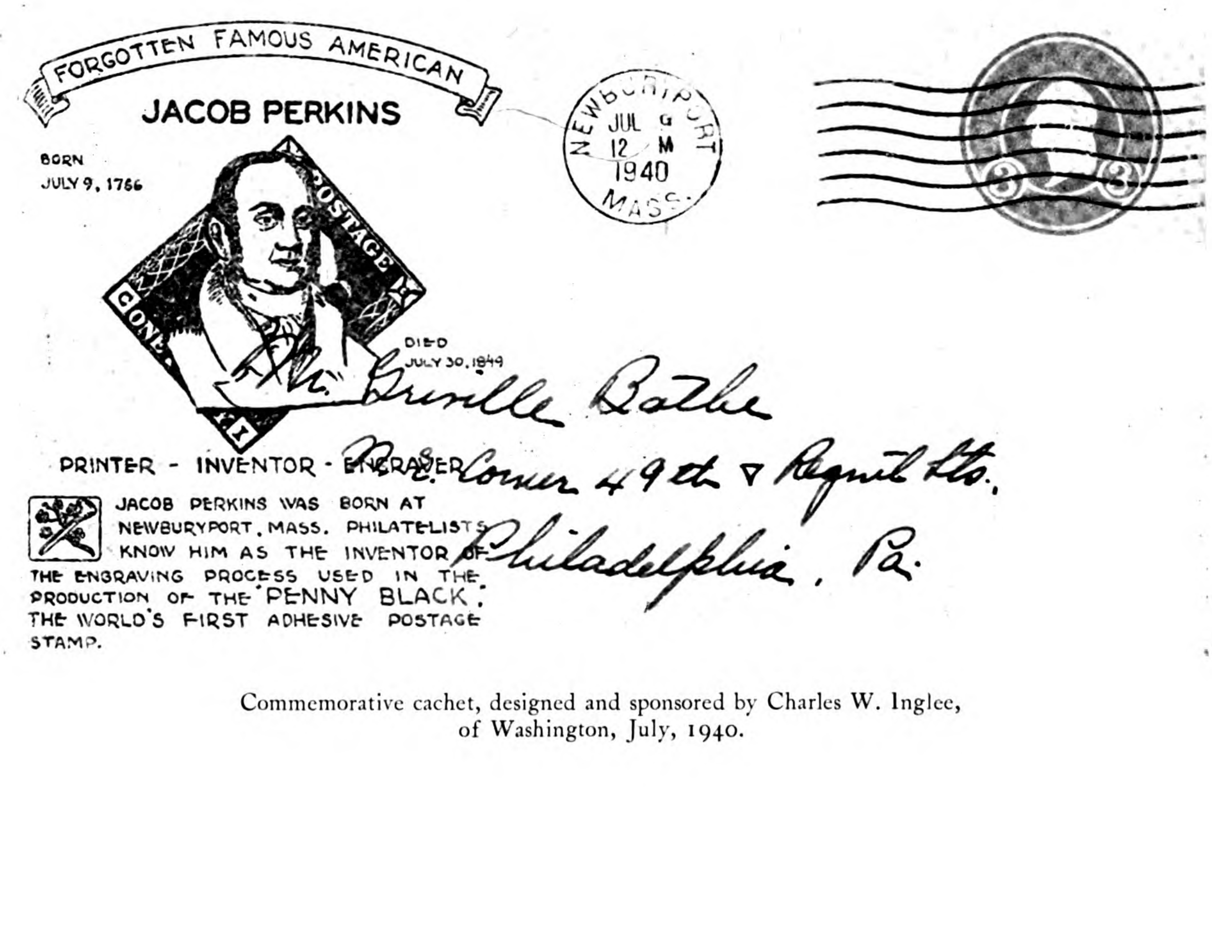
> Sometimes back-dates are dry things, so we need not care about the precise year—there existed in the neighborhood of the Lowther Arcade an establishment called the Adelaide Gallery. It was at first devoted to the diffusion of knowledge. Clever professors were there, teaching elaborate sciences in lectures of twenty minutes each; fearful engines revolved, and hissed, and quivered, as the fettered

Loftus into partnership in 1866 and the firm then became A. M. Perkins and Son. After the death of his father in 1881, Loftus Perkins carried on the engineering business and when he died in 1891 his two sons, Ludlow and Loftus, Jr., entered the firm and after several changes of name, the business was amalgamated with Joseph Baker Sons, and Company, under the title of Baker Perkins Limited, now of Peterborough, Northampton, with American branches at Saginaw, Michigan, and other places, who now manufacture ovens for the confectionery, bakery and chemical trades, also heating and ventilating apparatus, hot closets and stoves.

[207] *Dictionary of National Biography*, London, 1896. Vol. XLV, p. 6.



The London Post Office as it looked in Perkins' day. From *The Penny Magazine*.



Commemorative cachet, designed and sponsored by Charles W. Inglee,
of Washington, July, 1940.

steam that formed their entrails grumbled sullenly in its bondage; mice led gasping sub-aqueous lives in diving-bells; clock-work steamers ticked round and round a basin perpetually, to prove the efficacy of invisible paddles; and on all sides were clever machines which stray visitors were puzzled to class either as coffee-mills, water-wheels, roasting-jacks, or musical instruments. There were artful snares laid for giving galvanic shocks to the unwary; steam-guns that turned bullets into bad sixpences against the target; and dark microscopic rooms for shaking the principles of teetotalers, by showing the wriggling abominations in a drop of the water which they were supposed daily to gulp down.

Then came a transition stage in the existence of the Adelaide Gallery, at first stealthily brought about. The oxy-hydrogen light was slyly applied to the comic magic-lantern; and laughing gas was made instead of carbonic acid. By degrees music stole in; then wizards; and lastly, talented vocal foreigners from Ethiopia and the Pyrenees. Science was driven to her wit's end for a livelihood, but she still endeavored to appear respectable. The names of new attractions were covertly put into the bills, sneaking under the original engines and machines in smaller type. But, between the two stools of philosophy and fun, Science shared the usual fate attendant upon such a position—she broke down altogether. Her grave votaries were disgusted with the comic songs and the admirers of the banjo were bored with the lectures. So neither went to see her; poor Science declined into the "Gazette"[208], and fled to America.

After this, relates Albert Smith, the Gallery was given over to dancing, "and all the steam engines and water works were cleared away, and the Adelaide Gallery was devoted entirely to the Goddess of the 'twinkling feet,' and called a Casino." In 1852 the old Adelaide Gallery was altered into a marionette theater and then into a shooting gallery. There is a touch of life's irony in this last, when one thinks of the reverberations of Perkins' steam gun which those historied walls had known so well. And finally the premises were purchased by Mr. Agostino Gatti and his brother for use as a restaurant and thus it remains today.

It is to be regretted that the last few years of Jacob Perkins' life yield no record. It may be assumed that by 1848 Perkins was enfeebled to the extent of rarely leaving the house in Regent Square, except a drive on sunny days and his occasional visits to the Francis Street Works. There is also little doubt that Perkins was at this late period entirely dependent financially upon his son, Angier March, as he was for his creature comforts to the thoughtful care of his daughter-in-law, Julia. Perhaps this statement may seem peculiar, in the light of the prosperous engraving business in Fleet Street which still carried Perkins' name, but everything seems to point to the conclusion that Perkins had not, for many years, any direct connection with the firm. The fact that he died intestate shows obviously that he did not own a partnership share or other assets in that quarter. It is probable that at the time of the steam engine experiments, he withdrew, probably with compensation from the other partners, to follow his new interest, which at that time seemed to offer a far greater and more profitable future.

On July 15, 1849, Jacob Perkins, complaining of fever chills, took to his bed with what proved to be acute enteritis and sixteen days later, on July 30th, he passed away at the age of 83 years. Angier March was present at the deathbed of his father and following the funeral services, Jacob Perkins was laid to rest in the family vault in Kensal Green Cemetery. This peaceful vale of rest was one of the first suburban cemeteries to be estab-

[208] The London *Literary Gazette* had always given prominence in its pages to things pertaining to science and inventions. This periodical was founded in 1817 and became extinct in 1862. During the 40's the *Gazette* was edited and published by Charles Knight, who was also the editor of the *Penny Magazine* for the Society for the Diffusion of Useful Knowledge.

lished for London in 1832, for by that period the congestion in the London burial grounds was so great that it was said to be easier to find space to live than space in which to die. The Perkins vault of pyramid form, capped by a shrouded urn, was first used for the interment of Perkins' daughter, Louisa Jane, in 1833, and it had not been necessary to open it again until Jacob Perkins' own death on July 30, 1849.

Perkins' decease made little stir in London, for he had been out of the public news for many years. Only one notice could be found, though there may be others. This was in the *Annual Register of the History and Politics of the Year*, of 1849, which reads:

> On July 30 at the house of his son, Regent Square, aged 83, Jacob Perkins, Esquire., formerly of the United States.

The indexes of the *Times* for 1849 do not reveal any mention of Perkins' death. The Institution of Civil Engineers also made no comment at the time which might imply that Perkins had ceased to be a member of that body some years before. However, out of consideration for his son Angier who had been a member of the Institution since 1840, one might have supposed the event would not have been allowed to pass unnoticed. Nevertheless, it was not until 1865-1866 there appeared under the title of "Memoirs" a fairly comprehensive account of Jacob Perkins' activities while he was a member of the Civil Engineers. On the other side of the Atlantic considerable more notice was taken of Perkins' death. There was a long obituary notice in the *Boston Courier*, consisting of one and a half columns, which was also reproduced in the *Newburyport Herald*. This was written by George Lunt, a celebrated lawyer, who was himself a native of Newburyport and who was at this time United States attorney for the District of Massachusetts. There was also a long obituary article in the *Scientific American* on September 8th and another in the *Farmer and Mechanic*, published in New York on October 11th, and many copied extracts from these appeared in other American newspapers and magazines.

The Patent Office Report of 1849 at Washington devoted three pages of small type to a general though not too detailed account of Perkins' work as an inventor and commented in these words:

> A simple and unostentatious notice of the demise of this remarkable man is all the tribute that the public press has yet paid to his memory. The merits of our ingenious countryman deserve more, he passed quietly away from the scene of his labors; but has left his mark upon the age.

monumentum aere perennius

London as Jacob Perkins knew it, with a Key to the Names and Places mentioned in the text. Each square equals one mile.

Square	
A-1	The Regent's Park Manufactory near the Coliseum. Location of the steam gun trials before the Duke of Wellington.
A-2	21 Great Coram Street, near Russell Square. The dwelling of Jacob Perkins and his son, Angier March Perkins.
	18 Regent Square, near Gray's Inn Lane Road. The home of Angier March Perkins, where Jacob Perkins died.
	6 Francis Street (not shown) near Gray's Inn Lane Road. The manufactory of Jacob Perkins, and later, of Angier March Perkins.
B-1	The Royal Institution, Albemarle Street, north out of Piccadilly.
B-2	4 Harpur Street (not shown) near Theobald's Road. Business premises of Angier March Perkins.
	The Adelaide Gallery, Agar Street (not shown) between Chandos Street and the Strand.
	The Royal Society of Arts on John Street, Adelphi Terrace, at the west end of the Strand.
	The Patent Office, at the junction of Holborn and Chancery Lane.
	The Royal Society's Rooms in Somerset House, on the east side of Waterloo Bridge.
B-3	69 Fleet Street, the permanent engraving plant, and, for a period, the home of Jacob Perkins.
	41 Water Lane, the site of the first steam engine experiments. This runs north and south between Fleet Street and White Friars Dock.
	The London Post Office, in St. Martins le Grand, at the south end of Aldersgate Street, and the east end of Newgate Street.
B-4	The Bank of England, at the west end of Threadneedle Street.
	29 Austin Friars, at the junction of Throgmorton Street and Broad Street.
	The Royal Exchange, on the south side of Threadneedle Street.
C-2	Lambeth, South London, where Perkins applied his high pressure steam injection system at the Borough Water Works.
C-4	St. Catherine Docks, where the public trial of the uniflow steam engine was made.
C-5	John Hague's Manufactory on Cable Street, Ratcliffe, where the Perkins ice machine was made.

Reproduced by courtesy of The Philadelphia Library Co.

APPENDIXES

In the SENATE of the UNITED STATES on January 9, 1837, SAMUEL BULKLY RUGGLES, made the following REPORT on the FIRE at the PATENT OFFICE, December 15, 1836.

The special committee appointed to examine and report the extent of the loss sustained by the burning of the Patent Office, and to consider whether any and what measures ought to be adopted to repair the loss, and to establish such evidences of property in patented inventions as the destruction of the records and drawings may have rendered necessary for its security, submit the following report:

In examining the subject referred to them the committee have been deeply impressed with the loss the country has sustained in the destruction, by the fire of the 15th December, of the records, originals, drawings, models, &c. belonging to the Patent Office. They not only embraced the whole history of American invention for nearly half a century, but were the muniments of property of vast amount, secured by law to a great number of individuals both citizens and foreigners, the protection and security of which must now become seriously difficult and precarious.

Every thing belonging to the office was destroyed—nothing was saved. There were one hundred and sixty-eight large folio volumes of records and twenty-six large portfolios, containing nine thousand drawings, many of which were beautifully executed and very valuable; there were also all the original descriptions and specifications of inventions, in all about ten thousand, besides caveats and many other documents and papers.

There were also two hundred and thirty volumes of books belonging to the Patent Office library, the cost of which was $1,000. Some of these were procured prior to the passage of the act of July 4, 1836, making an appropriation of $1,500 for procuring a library of scientific works. Others were procured subsequently, for which $320 of that appropriation was expended.

The model-cases, press and seals, desks, book-cases, and other furniture and effects belonging to the office were estimated at $6,600.

The foregoing are more particularly described in schedules A, B, and C, annexed to a letter from the Commissioner of Patents, in reply to inquiries made by the committee, which accompanies this report.

The Patent Office contained also the largest and most interesting collection of models in the world. It was an object of just pride to every American able to appreciate its value as an item in the estimate of national character, or the advantages and benefits derivable from high improvement in the useful arts—a pride which must now stand rebuked by the improvidence which exposed so many memorials and evidences of the superiority of American genius to the destruction which has overtaken them.

The number of models was about seven thousand. Many of them displayed great talent, ingenuity, and mechanical science. The American inventions pertaining to the spinning of cotton and wool and the manufacture of fabrics, in many respects exceed those of any other nation, and reduced so much the expense of manufacture, that the British manufacturers were reluctantly obliged, at the expense of a little national pride, to lay aside their own machinery and adopt our improvements, to prevent our underselling them even in their home market. In this department were the inventions of Browne, Thorpe, Danforth, Couilliard, Calvert, and some others. The beautiful operative model of Wilkinson's machine for manufacturing weavers' reeds by one operation, was considered one of the most ingenious mechanical combinations ever invented. Of this character was Whittemore's celebrated machine for making wool cards. There were several models of valuable improvements in shearing and napping cloth, patented to Swift, Stowell, Dewey, Parsons, Daniels, and others.

In another department were several models of machines for manufacturing cut and wrought nails. The machinery for this purpose, which has reduced so much the price of that important article, was of purely American origin, and was invented by Briggs, Perkins, Reed, Odiorne, and several others . . .

(From—PUBLIC DOCUMENTS printed by order of THE SENATE OF THE UNITED STATES, second session of the twenty-fourth Congress, . . . December 5, 1836. Volume I, Document 58, pp. 1-2. Washington: Printed by Gales and Seaton. 1837.)

Some HISTORICAL REFERENCES to early NAIL MAKING and MACHINES, with Names and Dates of PATENTEES, 1588-1815

In 1588 Sir Bevis Bulmer, who followed the profession of a mining engineer, was granted the equivalent of letters patent from the Crown for an engine or instrument for the making of Nails, to be worked by water power. This patent ran for twelve years and an extension was granted in 1606 for a similar period but there is no record that a machine was ever built or used up to the time of Bulmer's death in 1615.

The first authentic mention of a slitting mill which was erected principally for making nail rods was at Dartford, Kent, this industry having been introduced into England by Godfrey Box from Liége in 1590.

On December 11, 1618, Clement Dawbeney obtained a patent for improvements on an engine or instrument worked by water power, for which prior letters patent, then expired, were originally granted to Sir Bevis Bulmer, whose invention consisted in cutting iron into small bars for rods, applicable to making Nails. This appears to have been the first British patent granted for a nail machine. From then until Thomas Clifford's patent of July 17, 1790, nothing can be found which would definitely prove that nails were made other than by hand labor. Clifford's machine consisted of two iron rollers geared together and having indented in the surface of each roll the shape of the nail. By rolling the rod through, a string of impressed nails was formed, which were afterward separated. Again, it does not appear that this machine was ever developed further, for nails made by hand alone reigned supreme until after 1830 when it is recorded that sixty thousand people were employed in the districts around Birmingham, Wolverhampton, Dudley and Wallsall.

Turning to a consideration of American nailmaking, it is evident that great efforts were made by ingenious men to produce nails by machinery alone, as the following list of patentees will indicate:

Samuel Briggs and Son, Aug. 2, 1791
*Thomas Perkins, Feb. 7, 1794
J. G. Pierson, Mar. 22, 1794
Jacob Perkins, Jan. 16, 1795
Jared Byington, Jan. 15, 1796
Peter Lachaine, May 4, 1796
Peter Cliff, Nov. 16, 1796
Isaac Garretson, Nov. 16, 1796
Amos Whittemore, Nov. 19, 1796
John Bigelow, Nov. 19, 1796
George Chandlee, Dec. 12, 1796
Daniel French, Dec. 23, 1796
Jared Byington, Dec. 23, 1796
J. Frost, Dec. 23, 1796
Lester Fling, Dec. 19, 1796
James Spence, Feb. 16, 1797
Jesse Kersey, Feb. 24, 1797
Jonathan Neville, Aug. 12, 1797
Nathan Read, Jan. 6, 1798
Seth Hart, Jan. 4, 1799
Jacob Perkins, Feb. 14, 1799
F. Young, Aug. 23, 1799
M. Garber, Feb. 20, 1801
M. Garber, May 1, 1801
Nathan Kent, May 1, 1801
Jesse Reed, June 9, 1801
W. Leslie, Nov. 5, 1801
Edward West, July 6, 1802
Nathan Forbes, Aug. 2, 1802
Benjamin S. Walcott, Sept. 4, 1802
William Caruthers, Dec. 13, 1802
Oliver, George and Otis Bartlett, Feb. 14, 1803
Lazarus Ruggles, Oct. 10, 1803
Joseph Elgar, Dec. 16, 1803
Michael Garber, Apr. 17, 1804
B. Allison and R. French, June 6, 1804
Nicholas Boureau, Aug. 21, 1804
F. W. Geyssenhayner, Dec. 22, 1804

* This Perkins came from Pennsylvania, and is not connected in any way with the Newburyport family as far as can be ascertained.

Increase Kimball, May 1, 1806
Jesse Reed, Feb. 22, 1807
Elisha Bigelow, Apr. 1, 1807
Jordan Dodge, July 8, 1807
Jonathan Nichols, July 11, 1807
Samuel Willard, Nov. 30, 1807
Samuel Rodgers, Dec. 15, 1807
Jonathan Hicks, Jan. 28, 1808
Joseph Jelleff, June 14, 1808
Asaph C. Hanaler and S. Shepard, Sept. 16, 1808
Jesse Reed, Apr. 15, 1809
Samuel Wilmot, Apr. 21, 1809
Luther Bissell, June 27, 1809
Briggs and Rodgers Reed, Mar. 8, 1810
Jacob Perkins, July 17, 1810
John Fairbanks, Aug. 14, 1810
Briggs and Rodgers Reed, Aug. 18, 1810
Jesse Reed, Sept. 16, 1810
William Miller, Sept. 26, 1810
I. P. Swain and J. Skinner, Feb. 8, 1811
A. Eastman, Apr. 8, 1811
E. Avery Lester, May 8, 1811
Jesse Reed, Aug. 14, 1811
Mark and Richard Reeve, Nov. 14, 1811
Robert Turner, Nov. 25, 1811
J. White, Jan. 11, 1812
Mark and Richard Reeve, Feb. 3, 1812
John Newalls, Nathan and
Daniel Chickering, Mar. 9, 1812
Mark and Richard Reeve, Oct. 31, 1812
Mark and Richard Reeve, Apr. 16, 1813
William Lutgen, Sept. 8, 1813
Mark and Richard Reeve, Sept. 28, 1813
Richard Moore, Jan. 13, 1814
S. Rogers, Jan. 26, 1814
R. Turner, Feb. 21, 1814
E. A. Lester, Apr. 2, 1814
Jacob Davey, Apr. 7, 1814
Stephan Belnap, Apr. 8, 1814
S. Rogers, Oct. 21, 1814
Jesse Reed, Oct. 22, 1814
Jesse Reed, Dec. 16, 1814
Nathan Elgar, June 19, 1815
John Elgar, June 21, 1815
Nathan Elgar, July 5, 1815
E. Bartholomew and W. Church Aug. 18, 1815
Henry Sedan, Sept. 6, 1815
Charles Phillips, Oct. 21, 1815
W. Warring and Charles Phillips, Oct. 21, 1815
Jacob Perkins, Jan. 16, 1815
Jacob Perkins, Nov. 1, 1815

It is not necessary to bring the list of patentees of Nail Machines further than the last patent obtained by Jacob Perkins in 1815. Only a small proportion of these inventions were ever put into practical operation, but they show a definite trend in America toward the machine-made nail and the elimination of hand labor.

From a retail price list issued in 1813 by William P. Israel of Philadelphia, who was then agent for the Phoenix Nail Works of Phoenixville, Pennsylvania, it will be noted that the prices per pound asked at this period for machine-made nails were only slightly less than were the prices asked by Armstrong and Perkins in 1798. The present average prices are given in the last column.

		1813	1798	1943			1813	1798	1943
2	Penny Nails—per lb.	14¢	——	10¢	8	Penny Nails—per lb.	8¢	11¢	7¢
3	” ” — ” ”	12½¢	——	8¢	10	” ” — ” ”	8¢	10¢	7¢
4	” ” — ” ”	10¢	12¢	8¢	12	” ” — ” ”	8¢	10¢	7¢
5	” ” — ” ”	10¢	——	8¢	20	” ” — ” ”	8¢	10¢	7¢
6	” ” — ” ”	10¢	12¢	7¢	24	” ” — ” ”	8¢	——	7¢
7	” ” — ” ”	9¢	——	7¢					

In 1800 or thereabouts a farmer was more than willing to trade a bushel of corn for a pound of nails, while today a bushel of corn would buy from 25 to 30 pounds of nails.

Nails made from endless coil wire in automatic machines, capable of producing half a million a day, have now superseded the cut or stamped nail for building purposes, but carpet tacks, some kinds of brads and horseshoe nails are still stamped or cut much in the old manner, but with the advantage of quantity production by automatic machines.

PETITION of GEORGE DODGE and others, of the AMESBURY NAIL WORKS, for an EXTENSION of their PATENT in 1806

1806, Jan. 13, Monday

9th congress 1st session
H J 126

A petition of George Dodge and others, of the state of Massachusetts, whose names are thereunto subscribed, was presented to the House and read, praying that the patents granted to Jacob Perkins, for the manufacture of nails, and assigned to the petitioners for a valuable consideration, may be renewed to them, for the reasons therein set forth.

Ordered, That the said petition be referred to the Committee of Commerce and Manufactures.

1806, March 17

9th congress 1st session
ASP Misc. v. 1 pg 453
House Report

Extension of Patent Rights

Communicated to the House of Representatives, March 17, 1806

Mr. Crowninshield, from the Committee on Commerce and Manufactures, to whom was referred the petition of George Dodge and others, merchants of Salem, in the State of Massachusetts, submitted the following report:

The petitioners were the proprietors of the valuable nail factory at Amesbury, in the state of Massachusetts. They have owned the works about three years, with the patent granted originally to Jacob Perkins of Newburyport, for a new and useful improvement in the mode of manufacturing nails; and they also are the assignees of another patent, granted to Samuel Guppy and John Warren Armstrong for a further improvement in the manner of cutting nails, discovered by the said Jacob Perkins. They have expended large sums of money in repairs and additions to their buildings; and the whole was in a capital state of improvement, when on the 24th of December last, the buildings accidently took fire, and were entirely consumed, with all their tools and machinery, and a considerable quantity of stock on hand. The loss is estimated at a sum exceeding $30,000. This was a most useful establishment; it supplied the neighboring country with large quantities of nails at a reasonable price, as they could be sold at a cheaper rate than imported nails; and the works being on an extensive plan, the supply was abundant. The petitioners are disposed to rebuild their works if they could be encouraged to proceed; and it would be a great inducement with them to commence the undertaking, if they could be permitted to renew their patent right for a period of seven or fourteen years from the time they will expire by the present limitation.

The first patent was granted on the 20th December, 1794 and will expire on the 14th December, 1808; and the second is dated 14th February 1799 and will expire on the 14th February 1813, each being limited to a period of fourteen years, agreeably to the act entitled "An act to promote the progress of useful arts, and to repeal the act heretofore made for that purpose passed the 21st February, 1793."

In considering the merits of this application, the Committee on Commerce and Manufactures will not give an opinion on a case not properly before them; but they may be permitted to observe, that,

had the loss actually happened to the original patentee, they should probably have deemed themselves justified in proposing to the House to grant the extension of the patent for a short period of time, with a view to encourage the inventors of useful machines to prosecute and extend their discoveries. But, although the committee acknowledge the present petitioners to have sustained a severe loss, they do not seem justly entitled to a renewal of their patents after the limitation may expire. No consideration could have been paid to the inventor at the time of the purchase of the patent right for the use of it, beyond the stipulated period of fourteen years. It is understood the right will then be in the public; every individual in the community ought then to be entitled to make use of the machine. Indeed, after being deprived of its advantages for fourteen years, unless under a title acquired by purchase from a patentee, it might be supposed that the citizens of the United States have a fair claim to participate in the enjoyment of a right, and in the free use of an invention, the benefits of which may have been so long exclusively withheld from them. It might be objected also, that other applications would be made to Congress, should the rule once be established that the purchaser of a patent right might calculate on its extension although no compensation had been allowed at the time of making the purchase, for the use of it beyond the period fixed by law. Under this view of the subject, the committee are induced to recommend that the petitioners have leave to withdraw their petition and the documents which accompany it.

1806, March 17 — 9th congress 1st session
H J 328

Mr. Crowninshield, from the Committee of Commerce and Manufactures, to whom was referred, on the thirteenth of January last, the petition of George Dodge and others, made a report thereon which was read and considered, Whereupon,

Resolved, That the petitioners have leave to withdraw their petition and the documents which accompany it.

JACOB PERKINS and the MASSACHUSETTS ACT of the year 1809

Commonwealth of Massachusetts

In the Year of our Lord One thousand eight hundred and nine.

An ACT requiring the several incorporated Banks in this Commonwealth to adopt the *Stereotype Steel Plate* in certain Cases; and for other Purposes.

WHEREAS *Jacob Perkins*, of *Newburyport*, in the county of *Essex*, hath invented and completed certain Stereotype Steel Plates for the printing of Bank Bills, and hath obtained from the President of the United States a patent for the exclusive use of the same; and whereas the said *Jacob Perkins* hath given a bond with sureties in the penal sum of *ten thousand dollars* to this Commonwealth, conditioned among other things, to print and impress with the said Plates, Bank Bills of the denominations of *Two, Three, Four,* and *Five Dollars,* for the use of the several incorporated Banks in this Commonwealth, and to furnish Bank paper for the same of the best quality, upon the terms which are specified and contained in the said bond; and whereas the public good requires that the Bills of the several denominations aforesaid should be printed and impressed from the said Plates, in order to produce a uniformity in, and prevent the counterfeiting of the same:

SECT. 1. ***Be it enacted*** *by the Senate and House of Representatives, in General Court assembled, and by the authority of the same,* That from and after the first day of *July* next, no Bills of the denominations of *Two, Three, Four,* and *Five Dollars,* shall be issued or emitted by the President, Directors and Company of any Bank incorporated under the authority of the Legislature of this Commonwealth, unless the said Bills shall be printed and impressed from Stereotype Steel Plates; from which Plates, original impressions of the Bills of the several denominations aforesaid are deposited in the office of the Secretary of this Commonwealth; nor unless the said Bills of the denomination of *Five Dollars* shall have on the back of the same, an impression from the Check Plates, one of the impressions from which is also deposited in the office of said Secretary of said Commonwealth.

SECT. 2. ***And be it further enacted,*** That the several incorporated Banks within this Commonwealth, which have heretofore issued their Bills in the names of the President and Directors of said Banks, shall, from and after the said first day of *July* next, issue all their Bills of the several denominations aforesaid, in the names of the President, Directors and Company of the same Banks; any thing in the respective Acts of incorporation of said Banks to the contrary notwithstanding.

SECT. 3. ***And be it further enacted,*** That from and after the said first day of *July* next, and during the pleasure of the Legislature after that time, the President, Directors and Company of all the Banks aforesaid, be, and the same hereby are authorized and empowered, to issue and emit Bills of the denominations of *Two, Three,* and *Four Dollars,* to the amount of *fifteen per centum* of their several capital stocks actually paid in; any thing in their respective Acts of incorporation, or any thing in an Act entitled, "An Act to authorize the several Banks incorporated within this Commonwealth, to issue Bills of the denomination of *One, Two* and *Three Dollars,*" made and passed on the fifteenth day of *June,* in the year of our Lord one thousand eight hundred and five, to the contrary notwithstanding.

SECT. 4. ***And be it further enacted,*** That from and after the said first day of *July* next, no person shall pay, or receive in discharge of any contract or bargain, or for any valuable consideration whatever, any Bill or Bills issued by any Bank or Banking Company other than the Bank of the United States, or the several incorporated Banks in this Commonwealth, of any less denomination than *Five Dollars,* under a penalty of *Twenty Dollars;* to be recovered of the person so paying the same by action of debt, with costs of suit, or by indictment by the Grand Jury, in the Supreme Judicial Court, Court of Common Pleas, or the Municipal Court in the town of *Boston,* to the use of the person or persons who shall within one year thereafter sue or prosecute for the same; in which suit or prosecution the person who shall receive the same Bill or Bills may be admitted as a competent witness. And the Bill or Bills which shall be paid as aforesaid shall be forfeited to the use of the person or persons who shall sue or prosecute as aforesaid.

SECT. 5. ***And be it further enacted,*** That an Act entitled, "An Act to prevent the circulation and currency of Bank Bills of a denomination less than *Five Dollars,*" made and passed on the eighth day of *March,* in the year of our Lord one thousand eight hundred and two, be, and the same is hereby repealed.

CASE of PATENT INFRINGEMENT brought by THOMAS ODIORNE against the AMESBURY NAIL FACTORY in 1819

This was an action of trespass on the case, brought by the plaintiffs[1] against the defendants[2] for the violation of a patent right obtained by one Jesse Reed, in the year 1814,[3] for a new and useful improvement in machinery for cutting, gripping, and heading nails of various sizes at one continued operation, and assigned by said Reed to the plantiffs.

The defendants pleaded the general issue, and filed the following specification of special matter, to be given in evidence:

1st—That the machine or combination of machinery claimed by the plaintiffs under the patent stated in the declaration in this cause, was not originally discovered by the said Jesse Reed, but by a certain Jacob Perkins, and that the said Jesse Reed has surreptitiously obtained said patent from the discovery of another person, to wit, of the said Jacob Perkins.

2d—That the machine, or combination of machinery claimed by the plaintiffs under the patent stated in the said declaration, was not originally discovered by the said Jesse Reed, but was described in a public work anterior to the said supposed discovery, to wit, in a certain patent issued by the Secretary of State, to a certain Jesse Reed, dated the 16th day of September, 1810, and also in a certain patent issued to Guppy and Armstrong, assignees of Jacob Perkins, dated 14th of February 1799.

3d—That the discovery or invention contained or described in the patent stated in the said declaration, is contained or described in a certain patent issued to the said Jesse Reed, dated 16th of September, 1810, which is still unrepealed and that a patent of the date last mentioned was granted to the said Jesse Reed, for the whole or part of the same invention or discovery patented by the patent stated in the said declaration.

4th—That the patent stated in the said declaration is broader than the discovery or invention of the said Jesse Reed, in this, that certain parts of the said alleged discovery or invention were in use prior to the said supposed discovery or invention; and that there is nothing in the said patent by which the said parts can be distinguished from other parts, of which the said Jesse Reed may have been the inventor, and that the parts so in use before the said discovery are the following, to wit, the horns, conductor, clearer,[4] and gauge.

5th—That the patent described in the plaintiff's declaration is also broader than the invention or discovery of the said Jesse Reed, in this, that a part of the improvement, alleged to have been invented and discovered by the said Reed, consists in the combination and application of certain parts of the machine described in his said patent, and of certain mechanical powers, which combination and application were in use prior to his alleged discovery.

6th—That the improvements, alleged by the plaintiffs to have been invented by said Reed, contain no new principle or application of principles, or mode of operation, or combination of machinery, not before known and in use.

7th—That the machine and combination of machinery, described in the plaintiff's patent and specification recited in the declaration, is the same with the machine and combination of machinery described in a certain patent and specification issued by the Secretary of State to the said Jesse Reed, dated 22nd of February, 1807, which patent, at the Circuit Court of the United States for the District of Massachusetts, at the October term thereof 1815 was adjudged to be vacated.[5]

Evidence was produced by the defendants, in the opening of the defence to prove that the plaintiffs, in the year 1810 had obtained a patent for the same invention and improvements contained

---

[1] George Sullivan, counsel for the plaintiffs.
[2] Benjamin R. Nichols, counsel for the defendants.
[3] Two patents are listed in this year, on October 22nd and on December 16th, both for cutting and heading nails.
[4] Perkins stated in the "Newburyport Herald" on September 15, 1815, that the "clearer" was invented by himself and formed a part of his nail machine patented July 17, 1810.
[5] In this case of Thomas Odiorne v. Enoch Winkley, the plaintiff lost as the jury found that the nail machine, then owned by Odiorne was not the original invention of Jesse Reed.

in the patent, for a violation of which this action was brought, and this fact was not denied by the plaintiffs.

Judge Story,[6] Independent of every other objection, there is one which seems admitted in point of fact, and is certainly established in evidence, that is decisive against the plaintiffs. It appears that the plaintiffs obtained a patent in September, 1810, substantially for the same invention and improvements, which are contained in the patent on which they now sue. That patent remains in full force and unrepealed. It cannot be, that a patentee can have in use at the same time two valid patents for the same invention; and if he can successfully take out, at different times, new patents for the same invention, he may perpetuate his exclusive right during a century, whereas the Patent Act confined this right to fourteen years from the date of the first patent. If this proceeding could obtain countenance, it would completely destroy the whole consideration derived by the public for the grant of the patent, namely, the right to use the invention at the expiration of the term specified in the original grant. I hold it to be the necessary conclusion of law that the inventor can have but a single valid patent for his invention; and that the first he obtains, while it remains unrepealed, is an estoppel to any future patent for the same invention, founded upon the general patent act. The public have, by the first patent, acquired an inchoate interest which cannot be defeated by any merely ministerial acts of the officers of the Government. [Suit dismissed]

[6] Judge Joseph Story (1799-1845) then presiding over the Circuit Court of the United States for the District of Massachusetts, May term 1819.

CASE of PATENT INFRINGEMENT brought by FRANCIS C. LOWELL against WINSLOW LEWIS in 1817

This was an action on the case for the infringement of a patent-right. In the year 1813, Mr. Jacob Perkins obtained a patent [1] for a new and useful invention in the construction of pumps, and afterwards assigned his interest therein to the plaintiff. The defendant became the assignee of a similar patent, taken out in 1817, by a Mr. James Baker: and it was for the constructing and vending pumps under this second patent,[2] that the action was brought. The principal object of both the inventions, was, by dispensing with the box used in the common pump, to obtain a larger water-way. To effect this, Perkins so constructed the valves of his pump, that they completely filled the area of the shaft, and fell upon its sides in the same manner, as by the old construction they did upon the box; thus leaving the whole of the area, excepting that occupied by the valves themselves, for a water-way. The valves were of a triangular shape, and adapted only to a pump of square form. This pump seemed to be principally useful, when it was desirable to throw up large quantities of water in a short space of time, and a number of hands could be put to the working of it.

The valves of Baker's pump were fitted to a round shaft, and occupied, like the other, the whole of its area; but instead of resting upon the sides of the shaft, were supported by a brass rim, which prevented the friction against the sides of the shaft consequent upon the other construction, and to obviate which, Perkins, since obtaining his patent, had adopted a check bolt. It appeared, that Baker's invention required fewer hands to work it, and could be applied to the common house pump.

Daniel Webster and G. Sullivan, for the defendant, contended that the invention of Perkins was neither new nor useful, and, therefore, not entitled to a patent. That the specification was so loose and insufficient, as not to answer the requisites of the law in this particular, and the patent, therefore, void on that account; and further that the invention of the defendant was substantially from that of the plaintiff.

[1] March 23rd at Newburyport, Mass.
[2] May 9th at Boston, Mass.

Benjamin Gorham, for the plaintiff, endeavored to show, that the improvement invented by Perkins was entirely new, and highly useful; and the specifications sufficient to answer the requisites of the law, which only required, that it should be so particular, as to that persons, acquainted with the construction of the same kind of machines, might be able to follow the description of it. And that, although differing in shape and some other unimportant particulars, it was, in principle, the same as that made and recorded by the defendant, under the patent of Baker.

A great number of witnesses were produced on both sides to sustain these positions. Judge Story,[3] in summing up the case to the jury, stated as follows: The present action is brought by the plaintiff for a supposed infringement of patent rights, granted in 1813 to Mr. Jacob Perkins (from whom the plaintiff claims by assignment) for a new and useful improvement in the construction of pumps. The defendant asserts, in the first place, that the invention is neither new nor useful; and in the next place, that the pumps used by him are not of the same construction as those of Mr. Perkins, but are of a new invention of a Mr. Baker, under whom the defendant claims by assignment. If the plaintiff is entitled to recover, the patent act gives him treble the actual damages sustained by him; and the rule for damages is, in this case, to allow the plaintiff treble the amount of the profits actually received by the defendant, and in consequence of his using the plaintiff's invention. The jury are to find the single damages, and it is the proper duty of the court to treble them, in awarding judgment. And let the damages be estimated as high as they can be, consistently with the rule of law on this subject, if the plaintiff's patent has been violated; that wrong doers may not reap the fruits of the labor and genius of other men.

To entitle the plaintiff to a verdict, he must establish that his machine is a new and useful invention; and of these facts, his patent is to be considered merely *prima facie* evidence of a very slight nature. He must, in the first place, establish it to be a useful invention; for the law will not allow the plaintiff to recover, if the invention be of a mischievous or injurious tendency. The defendant, however, has asserted a much more broad and sweeping doctrine; and one which I feel myself called upon to negative in the most explicit manner. He contends, that it is necessary for the plaintiff to prove that his invention is of great utility; so that, in fact, for the ordinary purposes of life, it must supercede the pumps in common use; in short, that it must be, for the public, a better pump than the common pump; and that unless the plaintiff can establish this position, the law will not give him the benefit of a patent, even though in some peculiar cases his invention might be applied with advantage. I do not so understand the law. The patent uses the phrase "useful invention" merely incidently; it occurs only in the first section, and there it seems merely descriptive of the subject matter of the application, or of the conviction of the applicant. The language is, "When any person or persons shall allege that he or they have invented any new and useful art, machine," etc., he or they may, on pursuing the directions of the act, obtain a patent. Neither the oath required by the second section, nor the special matter of defense allowed to be given in evidence by the sixth section of the act, contains any such qualification or reference to general utility, to establish the validity of the patent. Nor is it alluded to in the tenth section as a cause, for which the patent may be vacated. To be sure, all the matters of defense or objection to the patent are not enumerated in these sections; but if such an one as that now contended for, had been intended, it is scarcely possible to account for its omission. In my judgment the argument is utterly without foundation. All that the law requires is, that the invention should not be frivolous, or injurious to the well being, good policy, or sound morals of society. The word "useful," therefore, is incorporated into the act in contradistinction to mischievous or immoral. For instance a new invention to poison people or to promote debauchery, or to facilitate private assassination, is not a patentable invention. But if the invention steers wide of these objections, whether it be more or less useful is a circumstance very material to the interests of the patentee, but of no importance to the public. If it be not extensively useful, it will silently sink into contempt and disregard. There is no pretense that Mr. Perkins' pump is a mischievous invention; and if it has been used injuriously to the patentee by the defendant it certainly does not lie in his mouth to contest its general utility. Indeed the defendant asserts, that Baker's pump is useful in a very eminent degree, and if it be

[3] Judge Joseph Story (1799-1845) then presiding over the Circuit Court of the United States for the District of Massachusetts, May term 1817.

substantially the same as Perkins', there is an end of the objection; if it be not substantially the same, then the plaintiff must fail in his action. So that in either view the abstract question seems hardly of any importance in this cause.

The next question is whether Mr. Perkins' pump be a *new* invention. In the present improved state of mechanics, this is often a point of intrinsic difficulty. It has been often decided, that a patent cannot be legally obtained for a mere philosophical or abstract theory; it can only be for such a theory reduced to practice in a particular structure or combination of parts. In short, the patent must be of a specific machine, substantially new in its structure and mode of operation, and not merely changed in form, or in the proportion of its parts. Mr. Perkins' pump is square, and it is agreed that a piston exactly fitted, and used as in his pump, cannot be found described in any scientific treatise, and has never been seen in operation. The butterfly valve, which approaches very near to it, has certainly been in use, and a triangular shape was well known in the perimeter valves. But the exact structure and position of the valve in a square pump, uniting the triangular and butterfly forms, is not known to have been used at any time previous to his invention, in the precise manner in which Mr. Perkins uses them. In short, the combination of structure which he uses, is alleged by the plaintiff's witnesses to be new; and if the jury are satisfied that it is substantially different from anything before known, in its mode of operation, then the plaintiff has surmounted this objection to his title to a recovery.

An objection of a more general cast (and which might more properly have been considered at the outset of the cause, as it is leveled against the sufficiency of the patent itself) is, that the specification is expressed in such obscure and inaccurate terms that it does not either definitely state, in what the invention consists, or describe the mode of constructing the machine, so as to enable skillful persons to make one. I accede at once to the doctrine of the authority which has been cited, that the patentee is bound to describe, in full, and exact terms in what his invention consists; and, if it be an improvement only upon an existing machine, he should distinguish what is new and what is old in his specification, so that it may clearly appear for what the patent is granted. The reason for this principle of law will be manifest upon the slightest examination. A patent is grantable only for a new and useful invention; and unless it be distinctly stated in what the invention specifically consists, it is impossible to say whether it ought to be patented or not; and it is equally difficult to know whether the public infringe upon or violate the exclusive right secured by the patent. The patentee is clearly not entitled to include in his patent the exclusive use of any machinery already known; and if he does, his patent will be broader than his invention, and consequently void. If, therefore, the description in the patent mixes up the old and the new, and does not distinctly ascertain for which, in particular, the patent is claimed, it must be void; since if it covers the whole, it covers too much, and if not intended to cover the whole, it is impossible for the court to say what, in particular, is covered as the new invention. The language of the patent act itself is decisive on this point. It requires that the inventor shall deliver a written description of his invention "in such full, clear, and exact terms, as to distinguish the same from all other things before known; and in the case of any machine, he shall fully explain the principle, and the several modes in which he has contemplated the application of that principle or character, by which it may be distinguished from other inventions."

It is, however, sufficient, if what is claimed as new appear with reasonable certainty on the face of the patent, either expressedly or by necessary implication. But it ought to appear with reasonable certainty, for it is not to be left to minute references and conjectures, from what was previously known or unknown; since the question is not, what was before known, but what the patentee claims as new; and he may, in fact, claim as new and patentable, what has been long used by the public. Whether the invention itself is thus specifically described with reasonable certainty, is a question of law upon the construction of the terms of the patent, of which the specification is a part; and on examining this patent, I at present incline to the opinion, that it is sufficiently described in what the patented invention consists.

A question nearly allied to the foregoing, is, whether (supposing the invention itself be truly and definitely described in the patent) the specification in such full, clear, and exact terms, as not only to distinguish the same from all things before known, but "to enable any person skilled in the art or science, of which it is a branch, or with which it is most nearly connected, to make, compound, and use the same." This is another requisite of the statute and it is founded upon the best reasons. The law confers

an exclusive patent right upon the inventor of anything new and useful, as an encouragement and reward for his ingenuity, and for the expense and labor attending the invention.

But this monopoly is granted for a limited term only, at the expiration of which the invention becomes the property of the public. Unless, therefore, such a specification is made, as would at all events enable other persons, of competent skill, to construct similar machines, the advantage to the public which the act contemplates, would be entirely lost, and its principal object would be defeated. It is not necessary, however, that the specification should contain an explanation level with the capacities of every person (which would, perhaps be impossible); but, in the language of the act, it should be expressed in such full, clear, and exact terms, that a person skilled in the art or science, of which it is a branch, would be enabled to construct the patented invention. By the common law, if anything material to the construction of the thing invented be omitted or concealed in the specification, or more be inserted or added than is necessary to produce the required effect, the patent is void. This doctrine of the common law our patent act has (whether wisely admits very serious doubts) materially altered; for it does not void the patent in such case, unless the "concealment or addition shall fully appear to have been made for the purpose of deceiving the public". Yet certainly the public may be as seriously injured by a materially defective specification resulting from mere accident, as if it resulted from a fraudulent design. Our law, however, is as I have stated; and the question here is, and it is a question of fact, whether the specification be so clear and full, that a pump-maker of ordinary skill, could, from the terms of the specification, be able to construct one upon the plan of Mr. Perkins'. The principal objection to the specification in this case, is, that it does not describe the check bolt, or the form or use, or size of the leather, or the mode of forming the edge and fixing it upon the valve, or the exact position and elevation of the valve.

Here the judge read the specification, and commented on the evidence applicable to these objections; and left it to the jury to say, upon the facts, whether the specification was materially defective, and, if so, whether it was by design to deceive the public. Judge Story then continued: Another (and, under the circumstances of this case, probably, the most material) inquiry is, whether the defendant has violated the patent-right of the plaintiff; and that depends upon the fact, whether the pump of Mr. Perkins and Mr. Baker are substantially the same invention. I say substantially the same invention, because a mere change of the form of the proportions of any machine cannot *per se* be deemed a new invention. If they are the same invention, then Mr. Perkins, being clearly the first inventor is entitled exclusively to the patent-right, although Mr. Baker may have been also an original inventor, for the law gives right, as among inventors, to him who is first in time.

The manner in which Mr. Perkins' invention is, in his specification, proposed to be used, is in a square pump, with triangular valves, connected in the center, and resting without any box on the sides of the pump, at such an angle as exactly to fit the four sides. The pump of Mr. Baker, on the other hand, is fitted only for a circular tube, with butterfly valves, of an oval shape, connected in the center and resting, not on the sides of the pump, but on a metal rim at a given angle so that the rim may not be exactly in contact with the sides, but the valves may be. If, from the whole evidence, the jury is satisfied that these differences are mere changes of form, without any material alteration in real structure, then the plaintiff is entitled to recover; if they are substantially different combinations of mechanical parts to effect the same purposes, then the defendant is entitled to a verdict. This is a question of fact, which we leave entirely to the sound judgment of the jury. [Verdict for the defendant.]

From *Patent Cases and Federal Cases* by James B. Robb, Vol. 1, pp. 300-301 and pp. 131-140.

The PREVENTION of FORGERY Communicated to THE SOCIETY for the ENCOURAGEMENT of ARTS, MANUFACTURES and COMMERCE in 1819 by PERKINS, FAIRMAN and HEATH

SIR;

THE Society for the Encouragement of Arts, Manufactures, and Commerce having devoted so much of their valuable time to investigating the different methods proposed for the prevention of the forgery of Bank notes, we, the proprietors of the Siderographic art, believe that a full account of our plan (which has been in successful operation many years in America, and is now adopted by many banks in this country) will not be thought unworthy of their attention.

We will, in the first place state what we consider to be the grand basis of *security* in this plan, and secondly, the means of executing it. Although it is certainly not a new idea, that the greatest security which could possibly be afforded in preventing forgery would be that of employing a combination of the talents of the first-rate artists in fabricating a bank note plate, and of having the notes always *identically* the same; yet we conceive the following plan to effect this object is entirely new. It is the power of re-producing and multiplying the works of the greatest artists, which constitute the strength of this system; it is the basis on which we build our hopes. The method of multiplying engravings is as follows:

A steel plate (the method of preparing which will be hereafter described), is engraved or etched in the usual way; it is then hardened. A cylinder of very soft steel, of from 2 to 3 inches in diameter, is made to roll backwards and forwards on the surface of the steel plate, until the whole of the impression from the engraving is seen on the cylinder in alto-relievo: after this cylinder has been hardened, it is made to roll backwards and forwards on a copper or soft steel plate, and a perfect fac-simile of the original is produced of equal sharpness. The following calculations will show to what extent this system of preventing forgery may be carried.

Suppose 20 of the best historical and other engravers were employed, each to engrave a vignette; each vignette to occupy 4 square inches, and each artist to expend 6 months on his vignette: let these 20 vignettes be transferred to two steel plates, one for the front of the note, and the other for the back; the result will be, that one man (could such an one be found) would be occupied 10 years, or 20 men 6 months, to produce a note of equal goodness. Is it possible to suppose any thing better can be adopted, than to make it unprofitable to be engaged in such business? If a bank note plate can be made to cost 10,000*l.* (which would be the case, if 20 artists, whose time would be worth 1,000*l.* per annum, were engaged 6 months each), would it not be much less likely to be imitated than one that would cost but 5 or 10*l.*? If a bank plate can be made to contain the work of 20 of the best artists in the world, could another plate of equal goodness be made without employing the same artists? It is hardly to be presumed that 20 such artists would be engaged in making a spurious note; but admitting it possible, it would not be a fac-simile, and might be easily distinguished from the true note, by any one acquainted with the original. One of the peculiar features of this invention is, that any one may be furnished with a perfect fac-simile of the whole or of any part of the original note; which will serve to identify the note if good: this is owing to the infinite number of impressions that may be obtained from the original engraving. Having shown that a plate may be made to cost 10,000*l.*, we will undertake to prove that it is not incompatible with economy. To show the economy of this plan in its best light, we must be allowed to apply it to the best advantage, which would be by its being adopted by a bank whose daily consumption is not less than 25,000 notes.

Suppose the first steel plate costs 10,000*l.*, the next 999 plates will only cost 10,000*l.*: then 1,000 steel plates will amount to 20,000*l.* Each steel plate will print at least 150,000 impressions; of course 1,000 plates would furnish 150,000,000 of impressions, which is the number that would be wanted in 20 years, at 25,000 impressions per day. Now, the cost of impressions from steel plates would be (where the above number is wanted) one penny for 31¼ impressions; whereas, if copper plates were used, which cost only 3*l.* each plate, the number of impressions for a penny would be but 8⅓, since a copper plate prints but 6,000 impressions before it is worn out.

Another very important consideration is, that steel plates admit of an improved method of printing, and when worked to the greatest advantage, will make a saving of 50 per cent; this saving, in 20 years, in printing the above number of notes would be 75,000*l.* which would not only pay the whole cost of making the plates, but leave a balance of 55,000*l.*

This system of making plates and of printing, will apply equally well to that of ornamenting standard works, particularly Bibles, prayer books, primers, catechisms, spelling books, natural history, and philosophy. In proportion to the number wanted, will be the advantage of adopting this plan. It is often the case in this country, that from 4 to 6 copper plates are worn out in one edition, and not half the impressions perfect. A hardened steel plate will print more *proof impressions* than the above number of copper plates can furnish, even of common impressions. This fact is demonstrated by the plates Nos. XXXIX and XL, accompanying this communication. The impressions from plate No. XXXIX, are of the first impressions taken from the plate. The impressions, plate No. XL, were taken after 35,000 impressions had been taken from it.

This plate will also show the practicability of identity. The four medallions by inspection will be found to be perfectly the same, *line for line and dot for dot.* By examining the machine engraving, particularly the chain; the two *styles* of work, viz. copper plate and letter-press printing will be seen beautifully combined. This is effected by the process of transferring and re-transferring. This kind of engraving is extremely difficult to imitate. This machine, which is denominated the geometrical lathe, was invented in America by Mr. Asa Spencer. Its powers for producing variety are equalled only by the kaleidoscope; but for beautiful patterns it surpasses every thing of the kind. It has one of the peculiarities of the kaleidoscope, viz. that the turning of a screw, like the turning of the kaleidoscope, produces an entire new pattern, which was never before seen, and perhaps would never be seen again. This pattern however may be perpetuated by the transferring process. We are now printing from a plate of the most delicate work, which has already printed above 100,000 impressions, and is yet sound. We cannot yet say, how long a well hardened steel plate will last, having never printed more than 500,000 impressions from the same plate: it should however, be observed, that this plate consisted principally of writing, or work quite as strong. It may also be observed, that the impressions are yet good. The manufacture of printed calicoes, ribbons, &c., as well as of earthenware, may be much improved by adopting this system; and we are happy to say that experiments are soon to be made thereof. This improvement in engraving will apply to about one quarter of the present number of plates used. The others must necessarily be of copper, as a sufficient number of impressions would not be wanted to defray the expense of a steel plate. Not less than a number of impressions which would wear out three copper plates would warrant the making a steel plate. But such is the number of subjects to which this art will apply, and the great inducement to publishers to embellish their works, where large editions are wanted, which they now can do in consequence of its economy, that instead of the demand of engravers being lessened, it will be very much enhanced.

The use of fine and delicate engraving for Bank notes, has been objected to, in consequence of the difficulty of printing on such highly sized paper. But this objection is entirely got over by our method of printing in the water leaf, and sizing after printing. This improvement has a triple advantage,—that of producing beautiful impressions, having on its surface, after printing, a better size, and preventing the ink from being so easily transferred.

In order to describe the method of preparing and hardening the steel plate and dies, the following particulars are necessary:

In order to decarbonate the surfaces of cast steel plates, cylinders, or dies, by which they are rendered much softer and fitter for receiving either transferred or engraved designs, we use pure iron filings, divested of all foreign or extraneous matters.

The stratum of decarbonated steel should not be too thick for transferring fine and delicate engravings; for instance, not more than three times the depth of the engraving: but for other purposes the surface of the steel may be decarbonated to any required thickness.

To decarbonate it to a proper thickness for fine engravings, it is to be exposed for four hours in a white heat, inclosed in a cast iron box, with a well closed lid. The sides of the cast iron box are made at least three quarters of an inch in thickness; and at least a thickness of half an inch of pure iron

filings should cover or surround the cast steel surface to be decarbonated. The box is to be suffered to cool very slowly, which may be effected by shutting off all access of air to the furnace, and covering it with a layer six or seven inches in thickness, of fine cinders. Each side of the steel plate, cylinder, or die, must be equally decarbonated, to prevent it from springing or warping in hardening. It is also found that the safest way to heat the plates, cylinders, or dies, is by placing them in a vertical position.

The best cast steel is preferred to any other sort of steel for the purpose of making plates, cylinders, circular or other dies; and more especially, when such plates, cylinders, or dies are intended to be decarbonated. For the reason given above, the steel is decarbonated, solely for the purpose of rendering it sufficiently soft for receiving any impression intended to be made thereon; it is therefore necessary that, after any piece of steel has been so decarbonated, whether it be in the shape of a plate, or a cylinder, or a die, it should, previously to being printed from, be again carbonated, or re-converted into steel capable of being hardened. In order, therefore, to effect this carbonization or re-conversion into steel, the following process is employed:—a suitable quantity of leather is to be converted into charcoal by the well-known method of exposing it to a red heat in an iron retort, for a sufficient length of time; or, until most of the evaporable matter is driven off the leather. Having thus prepared the charcoal, it is reduced to a very fine powder; then take a box made of cast iron, of sufficient dimensions to receive the plate, cylinder, or die, which is to be re-converted into steel, so as that the intermediate space between the sides of the said box, and the plate, cylinder, or die, may be about one inch. This box is to be filled with the powdered charcoal, and having covered it with a well fitted lid, let it be placed in a furnace similar to those used for melting brass, when the heat must be gradually increased, until the box is somewhat above a red heat; it must be suffered to remain in that state till all the evaporable matter is driven off from the charcoal. Then remove the lid from the box, and immerse the plate, cylinder, or die, into the powdered charcoal; taking care to place it as nearly in the middle as possible, so that it may be surrounded on all sides by a stratum of the powder, of nearly an uniform thickness. The lid being replaced, the box, with the plate, cylinder, or die, must remain in the degree of heat before described, for from three to five hours, according to the thickness of the plate, cylinder, or die so exposed. Three hours are sufficient for a plate of half an inch in thickness; and five hours when the steel is one inch and a half in thickness. After the plate, cylinder, or die has been thus exposed to the fire for a sufficient length of time, take it from the box and immediately plunge it into cold water. It is important here to observe, that it is found by experience that the plates or other pieces of steel when plunged into cold water, are least liable to be warped or bent when they are held in a vertical position, or made to enter the water in the direction of their length. If a piece of steel, heated to a proper degree for hardening, be plunged into water, and suffered to remain there until it becomes cold, it is found by experience to be very liable to crack or break; and, in many cases, it would be found too hard for the operations it was intended to perform. If the steel cracks or breaks, it is spoiled. In order to render it fit for use, should it happen not to be broken in the hardening, it is the common practice to heat the steel again, in order to reduce or lower its temper, as it is technically called. The degree of heat to which it is now exposed determines the future degree of hardness, or the temper, and this is indicated by a change of colour upon the surface of the steel. During this heating a succession of shades is produced from a very pale straw colour to a deep blue. It is found, however, by long experience, that on plunging the heated steel into cold water, and suffering it to remain there no longer than is sufficient for lowering the temperature of the steel to the same degree as that to which a hard piece of steel must have been raised, in order to temper it in the common way; it not only produces the same degree of hardness in the steel, but, what is of much more importance, almost entirely does away the risk or liability of its cracking or breaking. It is impossible to communicate by words, or to describe the criterion by which we can judge of, or determine, when the steel has arrived at the proper degree of temperature, after being plunged into cold water; it can only be learned by actual observation, as the workman must be guided entirely by the kind of hissing or singing noise, which the heated steel produces in the water while cooling. From the moment of its being first plunged into the water, a varying sound will be observed; and it is at a certain tone before the noise ceases, that the effect to be produced is known. The only directions which can be given, whereby the experimentalist can be benefitted, are as follow: namely, to take a piece of steel which has already been hardened by remaining in the water till cold; and, by the

common method of again heating it, to let it be brought to the pale yellow, or straw colour, which indicates the desired temper of the steel plate to be hardened by the above process; as soon as he discovers this colour to be produced, to dip the steel into water and attend carefully to the hissing, or, as some call it, singing noise, which it occasions; he will then be better able, and with fewer experiments, to judge of the precise time at which the steel should be taken out. It is not meant to be understood that the temper indicated by a straw colour, is that to which the steel plate, cylinder, or die, should be ultimately reduced; because it would then be found too hard; but merely that the temperature which would produce that colour, is that by which the peculiar sound would be occasioned when the steel should be withdrawn from the water for the first time. Immediately on withdrawing it from the water, the steel plate, cylinder, or die, must be laid upon, or held over a fire, and heated uniformly, until its temperature is raised to that degree at which tallow would be decomposed; or, in other words, until smoke is perceived to arise from the surface of the steel plate, cylinder, or die, after having been rubbed with tallow. The steel plate, cylinder, or die, must then be again plunged into water, and kept there until the sound becomes somewhat weaker than before. It is then to be taken out, and heated a second time to the same degree, by the same rule of smoking tallow as before; and the third time plunged into water, till the sound becomes again weaker than the last. Expose it a third time to the fire as before; and, for the last time, return it into the water and cool it; after it is cooled, clean the surface of the steel plate, cylinder, or die; and by heating it over the fire, the temper must be finally reduced by bringing on a brown, or such other lighter or darker shade of colour, as may best suit the quality of the steel, or the purpose to which it is to be applied.

This letter was published in the Society's Journal Vol. XXXVIII, 1820 in that Section called the Polite Arts. It was accompanied by numerous examples of engraving made by Perkins, Fairman and Heath but these cannot be reproduced satisfactorily to show the delicate tracery of the designs and has therefore been omitted.

INVENTIONS for which JACOB PERKINS received MEDAL AWARDS from the ROYAL SOCIETY OF ARTS DURING 1820-1821.

No. 29, Austin Friars,
Dec. 22nd, 1819.

SIR;

HAVING made some improvements in the Leather Hose for Fire Engines, which I have found to answer well in America, I am desirous of submitting them to the notice of the Society for the Encouragement of Arts, Manufactures, and Commerce; and will attend to explain them before the Committee to whom the Society may refer them, upon being informed when they will be taken into consideration.

I am, Sir,
&c. &c. &c.
JACOB PERKINS.

A. Aikin, Esq.,
Secretary, &c. &c.

The improvement in this hose is in rivetting, instead of sewing it; and in connecting the hose with a new modification of the swivel joints, in such a manner as not to contract the water way at the joints. The first idea of rivetting hose, belongs to Messrs. Pennock and Sellers, of Philadelphia, and has been in successful practice 12 or 13 years, but without the leathers being overlapped sufficiently. The method of connecting the hose belongs to Mr. Perkins. The advantage of rivetting over sewing, is, that the seam lasts much longer, and is much tighter. The rivets, which should be made of copper, will last 4 or 5 times longer than the best thread. If care is taken to have sufficient overlap (see fig. 8), the pressure of water against the overlap, acts as a valve to tighten the seam. It has been found by experience, that the portion of hose next the engine, is much the most likely to burst, especially when the water is carried perpendicularly; to obviate this difficulty, the 1st, 3rd, or 4th portions (see fig. 1) are double-rivetted.

The method of connecting the different portions of hose is as follows: figs. 2 and 3 show sections of the male and female connecting screw and swivel joint; A forms the female part of the swivel joint, which is attached to the hose, by being screwed within the female screw *c c;* it is prevented from collapsing, by the brass ring *d* within it. On the outer side of this female screw is a groove *b b,* in which revolves the swivel ring *a a;* this swivel ring is fixed to the female connecting screw B, by means of rivetting over the end of it at *f*. The male screw C, is attached to another portion of hose, in the manner before described.

Fig. 4, end view of the hose as rivetted, showing also the overlap.

Fig. 5, section of that part where the hose is fixed to the connecting screws. The brass ring *d,* expands the hose, *g,* sufficiently to allow a screw to be cut on the leather embracing the ring *d,* by the female screw B.

Fig. 6 shows the manner of holding the hose while in the act of screwing it into the connecting screw (see A and C, in fig. 2). D, a block or cylinder of wood just large enough to pass through the ring *d;* this block prevents the hose from collapsing while it is held (in a vice, or otherwise), for the purpose of resisting the action of forcing on the screw *c c*.

Fig. 7 shows the means of connecting the different pieces of leather that compose the hose, which is effected by a spiral joining of double rivets.

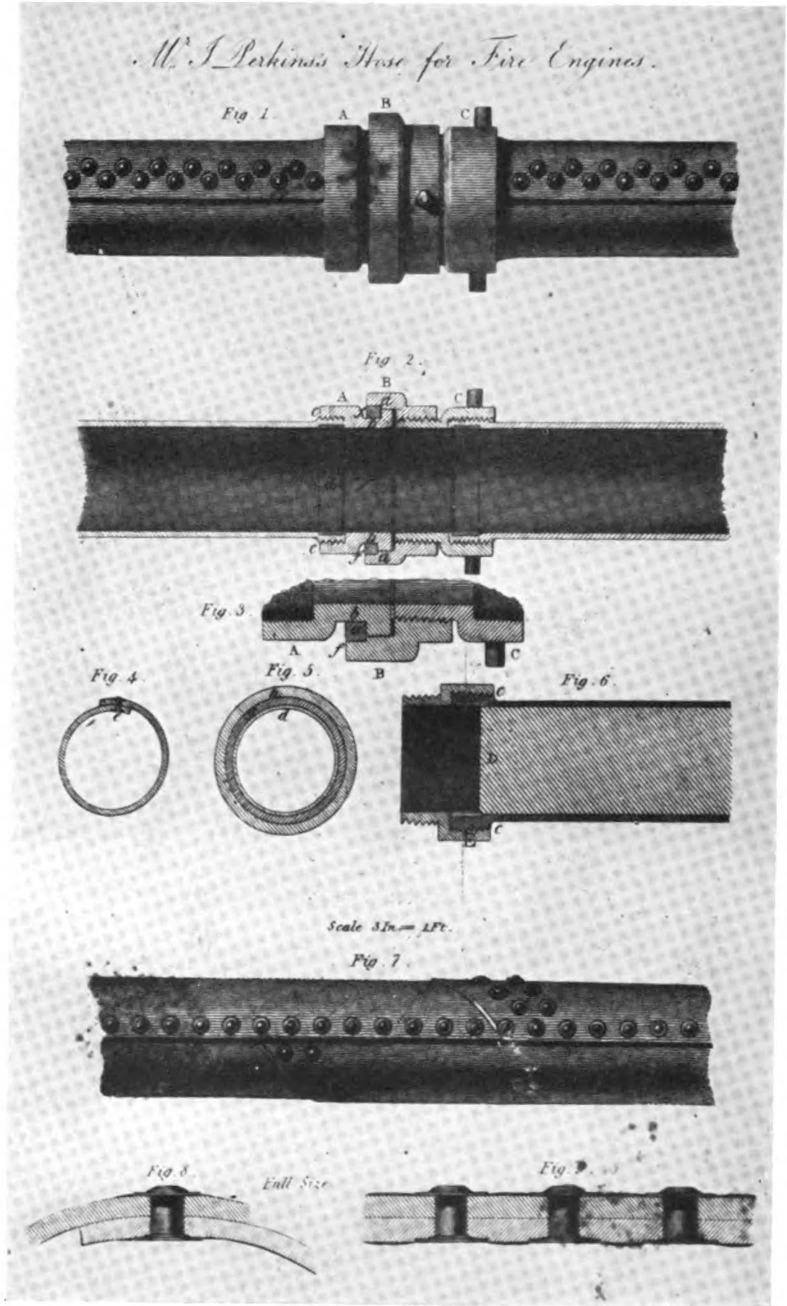

Mr. J. Perkins's Hose for Fire Engines.
Fig. 1
A
B
C
Fig. 2
A
B
C
Fig. 3
A
B
C
Fig. 4
Fig. 5
Fig. 6
Scale 3 In. = 1 Ft.
Fig. 7
Fig. 8
Full Size
Fig. 9

Plate XVI.

Fig. 8, end section (full size) of the hose, showing the overlap or valve.

Fig. 9, side section (full size) of the rivet seam.

When a rivet breaks, it is replaced by making an opening in the seam, of sufficient size to allow the hand to replace not only the broken rivet, but the rivets taken out to enlarge the opening. After the rivets are fixed in the holes, they are rivetted by placing them on a flat bar of iron, introduced in the entrance of the hose, and capable of being removed at pleasure. Copper has been found to answer best. It is of such importance that the rivet and burr should be of the same material, that it would not answer well to have the rivets of *cast* copper (they being an alloy of tin and copper), and the burr of *wrought* copper. Tin rivets, with copper burrs, will completely destroy the leather in a few months, occasioned undoubtedly by the operation of galvanism.

Reference to the Engraving of Mr. PERKINS' *Improved Hose for Fire Engines,* Plate XVI.

Fig. 1, a view of two pieces of double-rivetted hose, united by swivel joints.

Fig. 2, section of the above, showing that at the swivel joints, the water way is not contracted.

A, B, the swivel joint and female connecting screw.

C, male connecting screw.

a a, swivel joint ring.

b b, groove for swivel joint ring.

Fig. 3, section of parts of the connecting screws, on an enlarged scale.

Fig. 4, end view of the rivetted hose.

Figs. 5 and 6, end and side sections of the hose, as fastened to the connecting screws.

Fig. 7, view of the method of joining the hose.

Fig. 8, end section of the hose.

Fig. 9, side section of it.

29, Austin Friars,
January 10, 1820.

SIR;

I BEG to submit, for the approbation of the Society for the Encouragement of Arts, Manufactures, and Commerce (of which I have the honour to be a member), a model of a Ship's Pump, which has the advantage of being capable of being constructed of materials always to be found on board, and by any ship's carpenter, without the necessity of boring the barrel, as in the usual pumps; the construction of the valves in the piston and foot valve will also be found exceedingly easy, and to afford a large water-way; and, although the principles on which they are constructed is a modification of one of the objects of a patent granted to me; yet, should the Society approve of it, I am willing to wave any advantage from it, in favour of the British public.

The construction of this pump is so simple and obvious, that it scarcely requires any explanation; but, should the Society require it, I shall be happy to attend the Committee appointed for its examination.

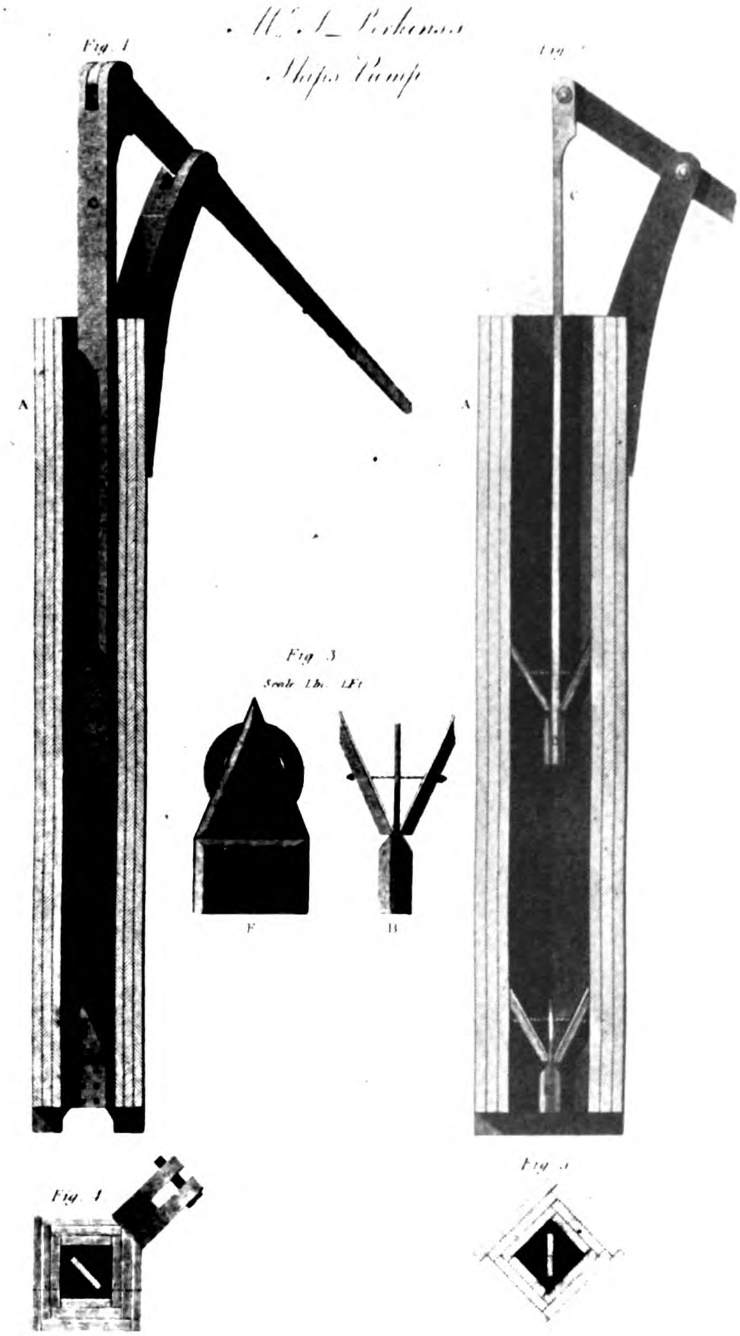
I am, Sir,
&c. &c. &c.
JACOB PERKINS.

A. Aikin, Esq.,
Secretary, &c. &c.

The object of the peculiar modification of this pump is that of enabling sea-faring people to construct a pump while at sea from materials always to be found on board; viz. deal boards or planks, leather, nails, canvas, and tar.

This pump is constructed as follows: take four strips of deal boards of suitable width and length, nail them firmly together, so as to form a square trunk; this trunk is next covered entirely with tarpaulin; then another layer of boards is nailed over the trunk, observing to break the joints (see figs. 4 and 5, pl. XVII). A third layer of boards nailed firmly to the first and second layer will complete the body of the pump, if of a common size (say 5 inches); but if the pump is larger, it may be strengthened by adding more layers of boards. For the form of the valves, see fig. 3. The substitute for the upper box of the common pump consists of two isosceles triangular valves the sides of which are double the length of the base, jointed with leather to two square pieces of boards (hard wood, if convenient). These two pieces of board, to which the valves ar jointed, play diagonally in the pump (see figs. 1 and 2). Between these two pieces of board, is fastened with nails, the pump rod, which is also made of deal board: the leather which forms the joint should be extended over the sides of the valves, so as to form the stuffing as the valves lie obliquely in the angles of the pump. The inside of the valves may be loaded with sheet lead, if convenient; at any rate, they should be filled with as many nails as the valves will hold without weakening them. The upper valves are furnished with a check string (see fig. 3, valve B), to prevent the friction of the valves on the sides of the pump; this check, which may be made of small line, is very important to the ease of working the pump. It should be so adjusted as to prevent the valves from resting on the sides of the pump, the leather only should touch the pump. The lower valves, which are fixed to the bottom of the pump, are made similar to the upper valves, with the exception of the rod and check. Between the lower valves a piece of hard wood, for hooking up the valves, if no sheet iron or copper is at hand, should be fastened (see fig. 3, valve F).

This pump works very easily, owing to the water way by the valves being much greater than the water way through common boxes. It is not liable to choke, in consequence of the water not being *wire-drawn* below the boxes or valves; for the water way below the valves may be so contracted as to draw up even iron; but, by enlarging the bottom of the pump, this will be remedied.



References to the Engraving of Mr. Perkins' *Ships' Pump,*
Plate XVII.

Fig. 1, a side section of the pump. Fig. 2, a diagonal section of ditto. A A, body of the pump, figs. 1 and 2. C C, pump rods. D D, upper valves. E E, lower valves. Fig. 3, upper and lower valves; B the upper, F the lower valve. Fig. 4, upper end of trunk. Fig. 5, lower end of ditto. The dotted lines mark the places in which the sections figs. 1 and 2 are taken.

Austin Friars,
March 8, 1820.

SIR;

I REQUEST that you will have the goodness to lay before the Society of Arts, &c., the inclosed communication relative to a method invented by me of drawing off the back water from water wheels.

This improvement in mills is that of using part of the superabundant water in times of floods, or freshets, to free the water-wheels from the back-water occasioned by such freshets. To effect this

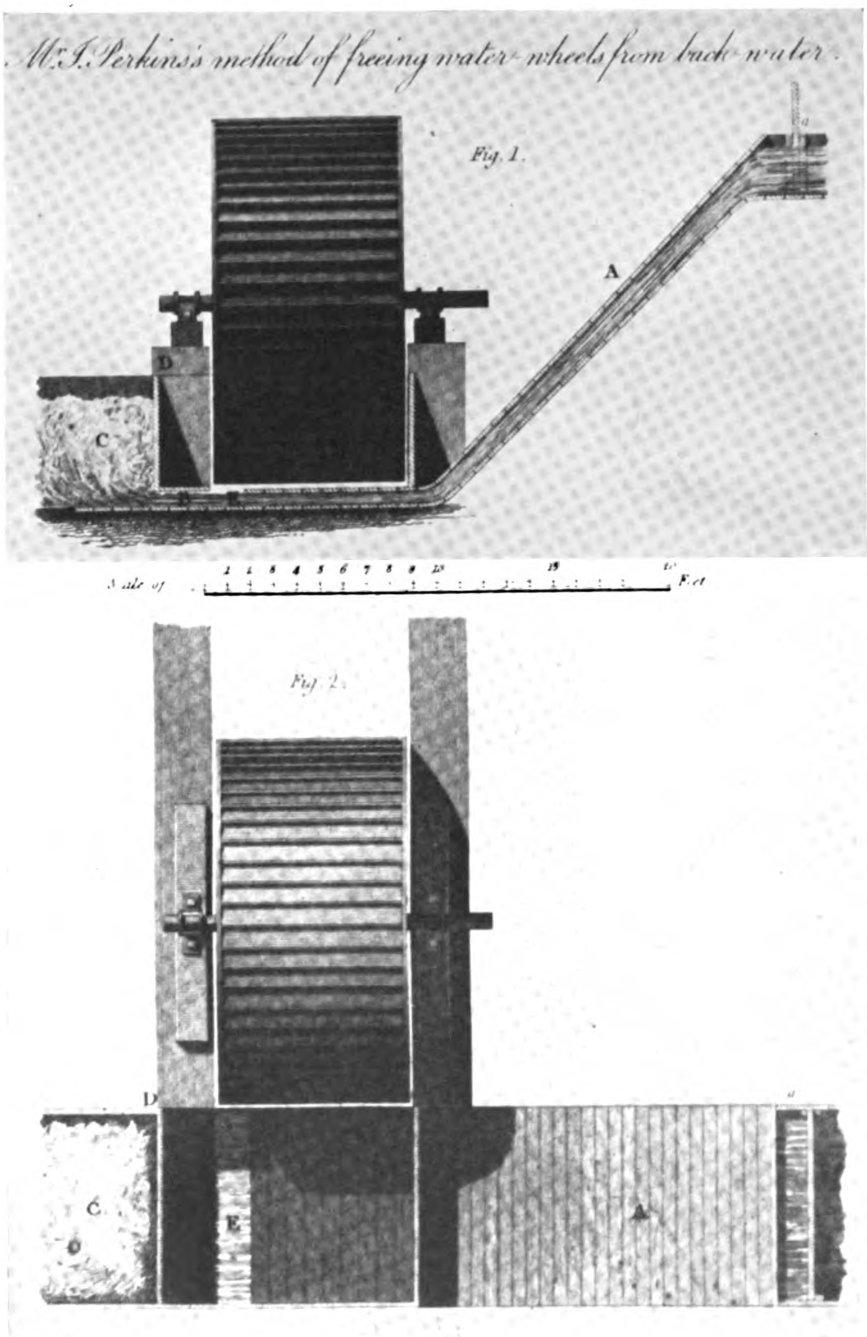


Plate XX.

purpose, the following plans have been successfully adopted: Plate XIX is a view of a section of a water-wheel, and the system of forcing off the back-water, which accumulates in time of floods. A represents a water-tight tube, or trunk, being the breadth of the wheel, and the depth of the buckets, running from the bottom of the penstock, to or past the center of the bottom of the wheel. B is a receiving tube, or trunk, being one third larger than the small end of the tube A, and is also in a direct line with it. E is an opening between the tubes A and B; at this opening the back-water (which had accumulated under the wheel, while the current was cut off by the gate *a*), is carried off by the lateral velocity of the current, which rushes from the tubes A and B. C represents the back-water; D the bulk head. It will be readily seen, that, by opening the gate *a*, the water will rush down the tube A, and join the back-water at E, and with it, pass off through the tube B, under the bulk head D. The water expended in turning the water-wheel will also be carried off by the same current through the tube B. Plate XX, fig. 1, is a back view of a water-wheel, with the tube A running at right angles to it; but this modification is only used when the wheels are already built. Fig. 2 is a plan of the same. In this case the water is brought from the dam, or reservoir, by a curved channel, or otherwise, as may suit the situation of the wheels. The same letters of reference apply to the same parts in both plates.

I am, Sir,
&c. &c. &c.
JACOB PERKINS.

A. Aikin, Esq.,
Secretary, &c. &c.

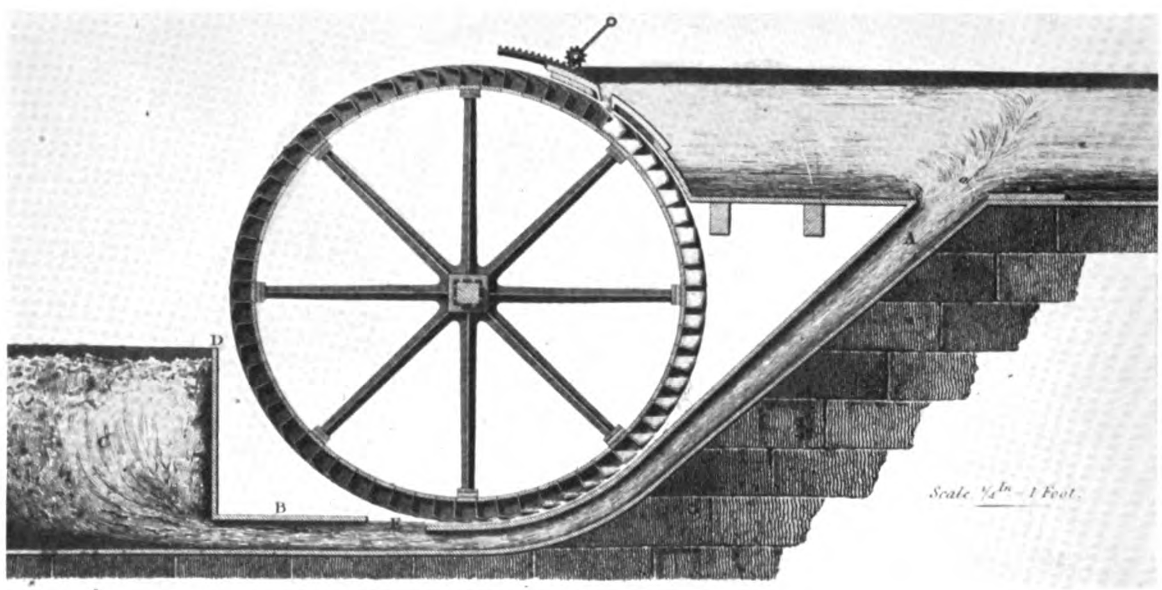


Plate XIX.

Austin Friars,
March 28, 1820.

SIR;

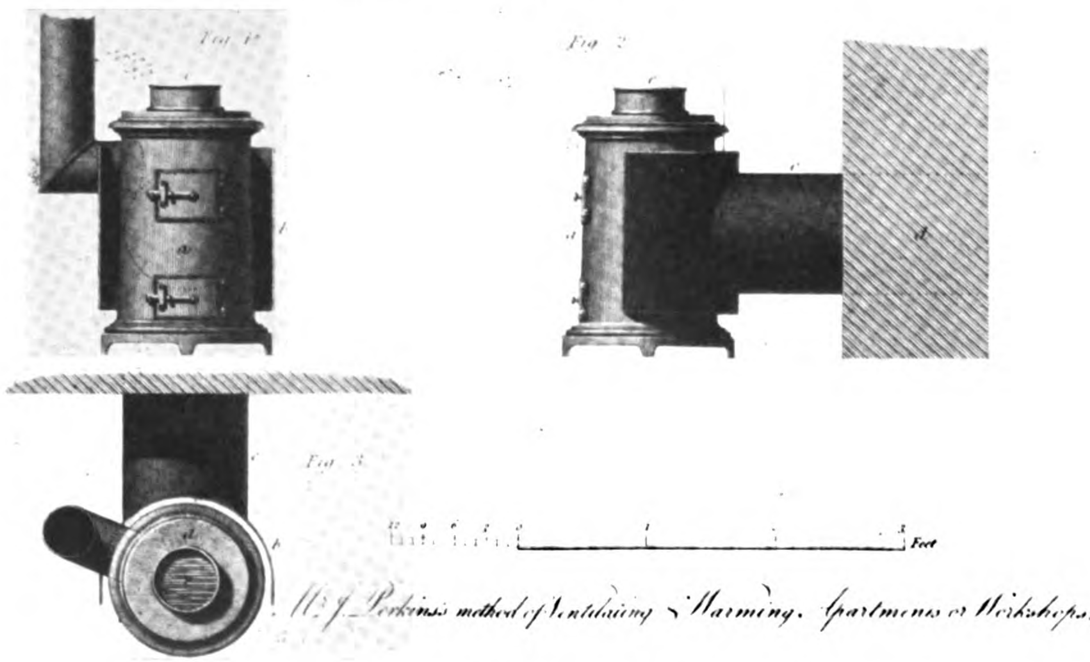
I REQUEST that you will have the goodness to lay before the Society of Arts, &c., the accompanying papers and drawings, descriptive of a method which has been practised by me with perfect success, of ventilating and warming apartments and workshops; and also a method of ventilating the holds of ships.

I am, Sir,
&c. &c. &c.
JACOB PERKINS.

A. Aikin, Esq.,
Secretary, &c. &c.

A method of Warming and Ventilating Apartments and Warehouses.

THIS improvement consists simply in introducing a large column of cold air immediately at the back of the stove, by which means the radiant heat from the stove is rapidly carried off. The greater the quantity of air which is made to strike against, and pass by the stove, the greater is the quantity of heat given out by it. This kind of stove will not work to good advantage when the room is air-tight: to remedy this evil, an aperture should be made near the ceiling. But where there is a chimney draft in the room, opposite the stove, or in the next or third room from the stove, the effect is very much increased, especially if a small fire is kept up in the chimney of that room. This constant current of warm air ventilates the rooms perfectly, and renders them pleasant and wholesome. It has also been found, that the air is very much improved by having a vessel of water placed on the top of the stove, so that evaporation may be constantly going on.

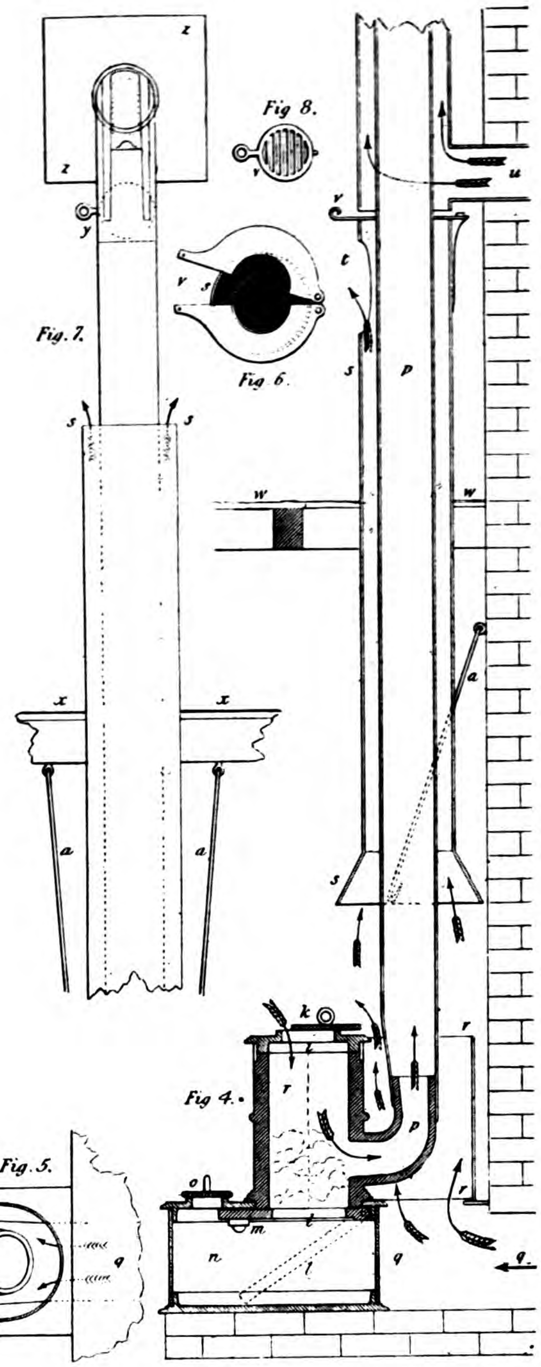


Reference to the Engraving of Mr. PERKINS' *Apparatus,* Plate VII.

Fig. 1, front view of the stove. Fig. 2, side view of ditto. Fig. 3, plan of ditto. *a a a*, the body of the stove. *b b b*, a sheet of iron affixed to the air conductor, and embracing 2/3 the diameter of the stove, and extending from top to bottom, leaving a space of two inches between it and the stove. *c c c*, the air conductor, being about the same diameter as the stove. It is also attached to the sheet of iron *b*. *d*, the wall into which the air conductor is fixed. *e e e*, a cup to be supplied with water from time to time, as the former portion evaporates.

Reference to the Engraving of Mr. JACOB PERKINS' *Warming and Ventilating Stove,* Plate VII.

Fig. 4, section of the stove; *i*, the mouth in which the fuel is put: *k*, the valve or lid to shut it; *l*, the grating hinged at the back, and held up in front by the iron button *m*; *n*, the ash-put, which is quite close, all but the opening *o*: this is opened and the lid *k* shut while lighting the fire; but when this is done, and the flue *p p* has become warm enough to produce a draught, the valve *o* is shut, and the valve *k* opened more or less, to supply or regulate the draught, by which means the smoke is effectually consumed; the lower part of the flue *p* is spread out at bottom nearly as wide as the stove (as seen in the plan fig. 5); *q q* is an air-trunk supplying fresh air from the outside of the house; this is directed by an iron screen *r r*, so as to impinge on the flue and stove and become effectually warmed as it passes in; *s s* is a hood or trunk surrounding the flue; this draws in much of the fresh air, and conducts it, still hot, through the ceiling into the next floor by the opening *t*, as shown by the arrows; above this opening is a register *v*, to stop the air from continuing its course to the third floor; or, if there is too much in the second, to let a portion escape to the third floor (a bird's-eye view, fig. 6, shows this register partly open); when the register *v* is closed another current of fresh air comes in from without through a second air-trunk *u*, and continuing its ascent, comes out warmed at *s s*, fig. 7, into the third floor; *w w*; fig. 4, is the floor of the second room, and *x x*, fig. 7, the third room floor, *y* is a grating or partial damper; it prevents the passage of lighted shavings or paper into the chimney, and is shown separate, fig. 8; *z z*, an iron plate through which the elbow passes into the chimney; there is an opening in the elbow, with a sliding cover; *a a*, figs. 4 and 7, are hooks of iron rod to bear the weight of the trunk *s s*.



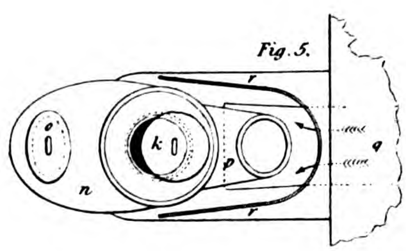
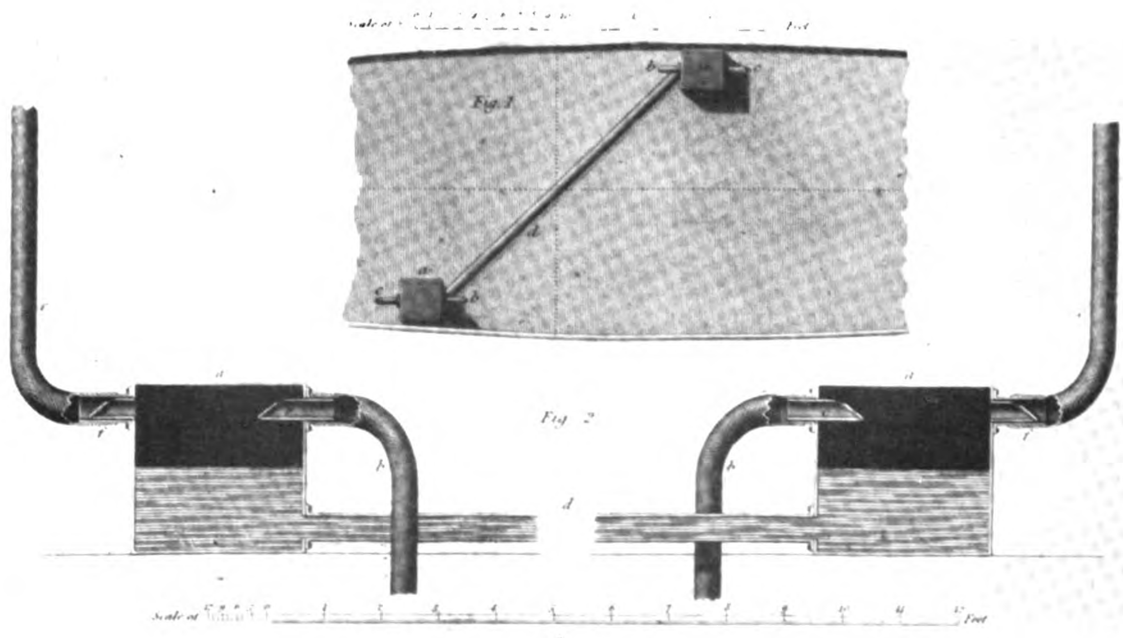


Plate VII.

The operation of this self-acting ventilator is as follows: Each tank or butt is half filled with water, which flows freely from one to the other through the pipe *d*. The quantity of water running alternately from each depends upon the motion of the ship. When one of the tanks is elevated by the ship's motion, the water will run through the pipe *d* into the depressed tank, and thereby discharge as much foul air through the valve *f* as the additional water displaces. The elevated tank at the same time is receiving the foul air through valve *e*, from the hold of the ship, to supply the vacuum that would otherwise be made by the escape of the water. If the tanks are fixed at right angles with the keel of the ship, the ventilator will operate only with the roll of it; but, if placed diagonally, both the pitch and roll of the vessel will discharge the foul air. It would be most economical to fill the tanks at the beginning of the voyage. The first water for the ship's use should be taken from the ventilating tanks, leaving, however, half of it behind for operation. If the remaining water should ever be wanted for the ship's use, it can be drawn off, and replaced by salt water. It will be seen that, by this mode of ventilating, nothing but the hose and valves are to be added to what must necessarily be on board every ship.



A method of Ventilating the Holds of Ships.

Plate VIII, fig. 1, a plan of part of a ship, showing a ventilator placed diagonally across it.
Fig. 2, section of a ventilator.
a a, tanks, or water butts.
b b, hose for conducting the foul air *into* the tanks.
c c, hose for conducting the foul air *from* the tanks.
d, connecting water pipe.
e e, valves for admitting the foul air into the tanks.
f f, valves for allowing the foul air to escape.

69, Fleet-street,
February 26th, 1821.

SIR;

IF the Society of Arts will have the goodness to examine two instruments (one of which is denominated an Orthometer, the other a Pleometer), calculated to facilitate the sailing of ships, &c. I shall take great pleasure in submitting them for their inspection.

I am, Sir,
&c. &c. &c.
JACOB PERKINS.

A. Aikin, Esq.,
Secretary, &c. &c.

As the construction of both these instruments is the same, differing only in the relative proportion of the parts, one description will serve for both. The instrument is in fact a mercurial level, consisting of a horizontal tube turned up vertically at each end, to the height of about three inches. This tube or syphon is filled with mercury, so that the fluid rises up about an inch in the two legs, to each of which a float is fixed, forming one end of a lever, as the index does the other end, which is so adjusted that the two indexes are in the same horizontal line when the mercury stands at the same height in both the legs; but when the mercury is unequal, then the indexes are, the one higher and the other as much lower than the horizontal line. Two instruments of this kind being fixed against the side of a ship's cabin, one in the same line with the keel, and the other at right angles to it, will show by changes in the relative position of the indexes, the angular changes in the position of the ship itself, occasioned either by the distribution of the cargo, or by the impulse of the wind on the sails.

The instrument is suspended by two points, one of which is fixed; the other is capable of being raised or lowered by an adjusting screw. As however, from the pitching and rolling of the ship, the mercury would be in a state of constant and violent oscillation, so as to render any accurate observations impossible, the inventor has obviated this difficulty by fixing a perforated screw upon the middle point of the horizontal part of the tube, by means of which the bore in that part can be diminished to any required degree, so as to render the instrument insensible to individual and sudden changes in the position of the ship, while it continues to indicate the average inclination of the vessel.

When the vessel is at sea, and sailing to the most advantage, the adjusting screw of the instrument is to be turned till the two indexes are brought into the same horizontal line, and this adjustment will ever after continue to indicate the trim of the vessel, as long as no material change in the quantity and position of the cargo takes place. Hence by mere inspection of the instruments so adjusted, the master will know whenever his ship is or is not sailing to the most advantage.

The instrument placed in a line with the keel of the ship is denominated by Mr. Perkins an Orthometer, that placed at right angles to the keel a Pleometer.

Reference to the Figures of the Instruments. Plate VIII.

Fig. 1, front view of the Orthometer; *a a*, front plate which protects and covers the machinery; *b*, screw pin on which the Orthometer is made to swing; *c*, adjusting screw for raising and depressing that end of the instrument to which it is attached; *d*, an aperture cut in the front plate, showing the two indices and the graduated arcs on which they traverse; *e*, the square head of the stop-cock, for regulating the passage of the mercury; *f f*, screws for fixing the floats when the instrument is not in operation, and to prevent the escape of the mercury.

Fig. 2, top view of the Orthometer; *m m*, the back plate in which the machinery is fixed.

Fig. 3, section of the Orthometer; *m m*, the back plate; *g g*, floats resting on quicksilver in the vertical tubes *h h*; *i i*, horizontal connecting tube; *j j*, indices or hands; *e*, regulating stop-cock; *k k*, fulcrums for the index hands; *l l*, screw pins for uniting the lower and upper parts of the instrument; *d*, index plate for denoting the trim of the ship.

Fig. 4, section showing, on a larger scale, the regulating stop-cock, *e*. The perforation is made conical to allow of more accuracy in its adjustment.

Fig. 5, bottom part of fig. 3.

Fig. 6, section, on an enlarged scale, of part of the Orthometer, showing one of the index hands *j*, and floats *g*, resting on the quicksilver in the vertical tube *h*.

Fig. 7, front view of the Pleometer; *a a*, front plate; *b b*, screw pins to fix the instrument to its place; *e*, regulating stop-cock; *d d*, index plate showing the careen of the ship.

Fig. 8, end view of the Pleometer.

Figs. 9, and 10, view of the Pleometer, the upper and lower parts of the case inclosing the machinery being separated; *g g*, floats for raising and depressing the index hands *j j*; *h h*, vertical tube containing quicksilver; *e*, regulating stop-cock; *i i*, horizontal tube connecting the vertical tubes *h h*; *k k*, fulcrums for the index hands; *d*, index plate; *l l*, connecting screw pins.

Fig. 11, section of one end of the Pleometer, and of part of one of the index hands on a larger scale; *g*, the float resting on the quicksilver in the vertical tube *h*; these floats are hollowed to admit the rods *n* to play therein, and preserve the parallelism of the motion of the floats in the vertical tubes *h h*.

Fig. 12, screw of the regulating stop-cock *e*, full size; *o*, conical aperture, through which the quicksilver flows in its passage from one vertical tube *h* to the other: by turning the screw more or less, the flow of the mercury is regulated so as to partake of the mean motions of the vessel, but not to be continually agitated thereby; and, by turning the screw *e* a little more upwards than is shown in fig. 4, the small conical hole will be entirely closed, and the flow of the mercury prevented.

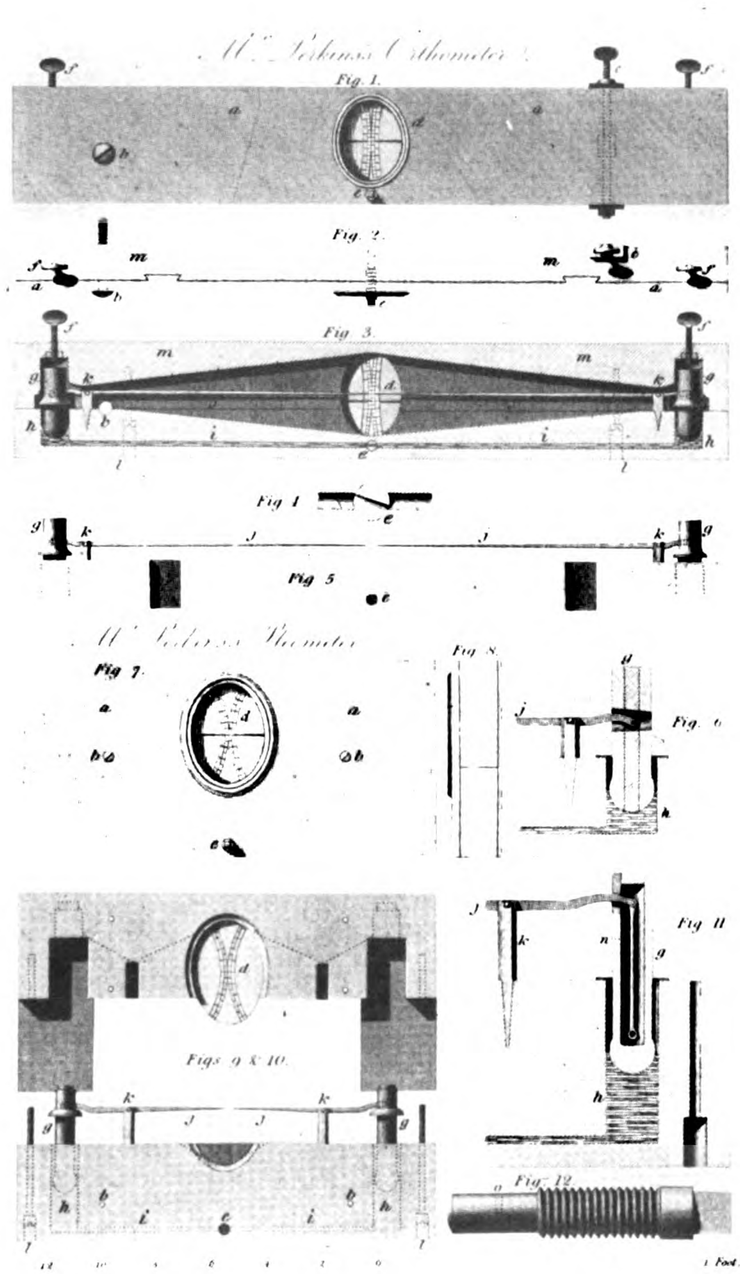


Plate VIII

DESCRIPTION of a MACHINE for COOLING LIQUIDS described by OLIVER EVANS in 1805, for comparison with a SIMILAR MACHINE by JACOB PERKINS in 1836

Water boils in vacuo at the temperature of 70 deg. and vapour may by compression be reduced to the fluid from whence it arose: hence we may infer, that water will keep cooler in vacuo than when exposed to the pressure of the atmosphere. If an open glass vessel be filled with ether and set in water in vacuo, the ether will boil rapidly and rob the water of its latent heat until it freezes. It is not right to say that the ether becomes so cold that it freezes the water around it. The heat in the water enters the ether, causing it to boil and the ether is converted into vapour, carrying off the heat to fill the vacuum. This is a positive proof that a vacuum will receive and retain in a latent state more heat than a plenum.

These principles may probably be applicable to useful purposes. For instance, to cool wholesome water, such as that of the Mississippi, rendering it palatable for drinking, to supply the city of New-Orleans; or of the Schuylkill to supply the citizens of Philadelphia. A steam engine may work a large air-pump, leaving a perfect vacuum behind it on the surface of the water at every stroke. If ether be used as a medium for conducting the heat from the water into the vacuum, the pump may force the vapour rising from the ether, into another pump to be employed to compress it into a vessel immersed in water; the heat will escape into the surrounding water, and the vapour return to ether again; which being let into the vessel in the vacuum, it may thus be used over and over repeatedly. Thus it appears possible to extract the latent heat from cold water and apply it to boil other water; and to make ice in large quantities in hot countries by the power of a steam engine. I suggest these ideas merely for the consideration of those who may be disposed to investigate the principles, or wish them put in operation. And, lest I should be thought extravagant, as was the case with the Marquis of Worcester, I give a

DESCRIPTION OF THE MACHINE.

Make an air-pump and close the lower end of the cylinder by connecting it with a globular glass vessel, if metal will not answer as well: fix the lower end of the cylinder of this pump, so that the glass vessel shall be immersed in the water that is to be cooled, and which is to be contained in a tight vessel. Near to this pump fix another much smaller, called the condensing pump, and connect it with a small vessel, called the condenser, immersed in water, fixing a valve between them. Connect the upper end of these working cylinders by a pipe with a valve therein at the top of the exhausting pump, and connect the bottom of the condenser with the glass globe, by a small pipe, in which insert a cock, called the ether-cock. The piston rods of the pumps must work through stuffing boxes made air-tight, and each piston must have a valve fixed in it, one to shut downward and the other upward: work these pistons by a lever that is to be put in motion by a steam engine or any other power.

THE OPERATION.

Fill the glass globe with ether, so that the piston will touch its surface at every stroke; expel the air from the pumps and condenser, making a complete vacuum in them. Set the machine in motion and every time the piston rises the exhausting piston leaves a perfect vacuum behind it: the ether then begins to boil and carry off the latent heat from the water; the steam of the ether fills the vacuum, which is again exhausted by the pump, and driven into the condensing pump which compresses it in the condenser, forcing out the heat which robs the vapour of its essential constituent part, and reduces it to ether again; the ether-cock being opened just sufficient to let the ether return to the glass globe to undergo the same operation; and so on ad infinitum. The machine might be simplified by connecting the top of the exhausting cylinder with the condenser, dispensing with the condensing cylinder and piston. The condensation might be sufficiently effected by the exhausting cylinder and piston alone forcing the vapour into the condenser. If the air be not expelled it will be forced into the condenser, and remain above the ether formed there without injuring the working or the effect of the engine: but I presume the condensing pump would be necessary to carry the principle to such extent as to boil water by the heat extracted from cold water. A small pump may be fixed so as to be worked by the same lever, to extract the water from the vessel as fast as necessary after it is cooled. The vessel may be kept full by the pressure of the atmosphere forcing the water through a valve at the bottom.

From "The Abortion of the Young Steam Engineer's Guide" by Oliver Evans, Philadelphia, pp. 136-139.

COMPLETE LIST of Twenty-one AMERICAN PATENTS filed by JACOB PERKINS between 1795 and 1838

Subject of Patent	*Date*	*Residence at Time of Filing*
Manufacturing Nails and Cutting Nails	Jan. 16, 1795	Newburyport, Mass.
Improvements in Making Nails	Feb. 14, 1799	Newburyport, Mass.
Bank Note Check Plate to Prevent Counterfeiting	Mar. 19, 1799	Newburyport, Mass.
Pumps	July 9, 1801	Newburyport, Mass.
Polishing and Graining Morocco Leather	June 26, 1809	Boston, Mass.
Method of Preventing Counterfeits	June 16, 1810	Boston, Mass.
Manufacturing Cut Nails, Cut Points, and Cut Brads	July 17, 1810	Boston, Mass.
Fire Engines (joint patent with Allan Pollock)	Aug. 6, 1812	Boston, Mass.
Pumps and Construction of Valves	Mar. 23, 1813	Newburyport, Mass.
Machine for Making Shanks of Screws, also Bank Vault Locks	Mar. 23, 1813	Newburyport, Mass.
Fire Engines	Mar. 23, 1813	Newburyport, Mass.
Method of Impressing all Kinds of Die Work on Steel and Copper by Circular Dies (joint patent with George Murray)	June 25, 1813	Newburyport, Mass.
Water Mills	June 26, 1813	Newburyport, Mass.
Manufacturing Spoons	June 29, 1813	Newburyport, Mass.
Printing Press for Copper and Steel Engraving (joint patent with George Murray)	June 29, 1813	Newburyport, Mass.
Manufacturing Nails, Cylindrical Nail Cutter	Jan. 16, 1815	Newburyport, Mass.
Manufacturing Nails, improvements to Cylindrical Nail Cutter	Nov. 1, 1815	Newburyport, Mass.
Watermarking Paper	Dec. 18, 1816	Philadelphia, Pa.
Progressive Lever Press for taking Imprints	Feb. 27, 1819	Philadelphia, Pa.
Screw Propeller	Nov. 30, 1829	Fleet St., London
Steam Boiler, Hermetically Sealed Water Tubes (assigned to Angier March Perkins)	Dec. 15, 1838	Great Coram St., London

COMPLETE LIST of Nineteen BRITISH PATENTS filed by JACOB PERKINS between 1819 and 1836

Subject of Patent	*Date*	*Residence at Time of Filing*
Ornamental Turning and Engraving Lathe; Construction of Plates and Presses; Making and using Dies and Presses for Coining and Stamping Metal	Oct. 11, 1819	Austin Friars, London
Portable Pumps	June 3, 1820	Austin Friars, London
Steam Engines (Concentrating engine)	Dec. 10, 1822	Fleet St., London
Boiling or Evaporating by Steam	May 17, 1823	Fleet St., London
Steam Engines, Improvements to	June 5, 1823	Fleet St., London
Furnaces of Steam Boilers (joint patent with John Martineau, Jr.)	Nov. 20, 1823	Fleet St., London
Discharging Projectiles by the Force of Steam	May 15, 1824	Fleet St., London
Propelling Vessels (Double Paddle Wheels)	Aug. 9, 1824	Fleet St., London
Bedsteads and Sofas (Improvements to)	Aug. 11, 1825	Fleet St., London
Steam Engines and Boilers (Uniflow Engine)	Mar. 22, 1827	Fleet St., London
Propelling Vessels (Screw Propeller)	July 2, 1829	Fleet St., London
Improvements to Boilers and Generating Steam (Drop Tube and Circulators)	July 2, 1831	Fleet St., London
Apparatus for Boiling Liquids (Brewing)	Aug. 27, 1831	Fleet St., London
Blowing and Exhausting Air	June 9, 1832	Fleet St., London
Preserving Copper from Oxidation	Nov. 20, 1832	Fleet St., London
Apparatus for Producing Ice and Cooling Liquids	Aug. 14, 1834	Fleet St., London
Steam Engines and Boilers (Hermetically Sealed Water Tubes)	Apr. 12, 1836	Fleet St., London
Apparatus for Cooking (No specification enrolled)	June 13, 1836	Fleet St., London
Steam Engines, Furnaces, etc. (Turbine Steam Engine)	Dec. 3, 1836	Fleet St., London

LIST of PAMPHLETS, PAPERS and other PRINTED WORKS of JACOB PERKINS between 1806 and 1837

1806 The Permanent Stereotype Steel Plate with Observations on Its Importance, and an Explanation of Its Construction and Uses. Printed by C. Stebbins, Newburyport 1806. Copies in the American Antiquarian Society, Worcester, Mass. and The Public Library of the City of Boston.

1809 Perkins' Bank Bill Test, Consisting of Original Impressions from the Permanent Stereotype Steel Plates of Massachusetts Paper Currency, together with the Standard Check Plate. Printed by W. and J. Gilman, Newburyport, 1809. Copy in the American Antiquarian Society, Worcester.

1810 Perkins' and Fairman's Running Hand Stereographic Copies. Printed by Thomas and Whipple, Newburyport, 1810. Copy in the American Antiquarian Society, Worcester.

1819 Opinion and Remarks upon the Means of Preventing Forgery. Printed in London October 23, 1819. Copy in the American Philosophical Society, Philadelphia.

1820 On the Compressibility of Water. Communicated to Sir Joseph Banks and read by proxy before the Royal Society in London on June 29, 1820. Printed in the *Transactions of the Royal Society* for that year. Copies in the University of Pennsylvania Library, Philadelphia; the Boston Public Library and elsewhere.

1824 An Account of the Concentrating Steam Engine, By the inventor Jacob Perkins. Printed by Thomas Davidson, Whitefriars, London, 1824. Consists of a Preface, and twenty-four pages and two plates. Copy (Plates missing)* in the Franklin Institute Library, Philadelphia.

1826 On the Progressive Compression of Water by High Degrees of Force with some Trial of its Effects on Fluids. Communicated to Dr. William Hyde Wollaston and read by proxy before the Royal Society in London, June 15, 1826. Printed in the *Transactions of the Royal Society* for that year. Copies in the University of Pennsylvania Library, Philadelphia and elsewhere.

1827 On the Explosions of Steam Boilers. Published in London in 1827 by the author for private circulation. Also printed in the *Register of Arts and Journal of Patent Inventions*, Vol. 1—new series. This pamphlet consists of eighteen pages and one plate. Copies in the Franklin Institute Library, Philadelphia and in the library of Greville Bathe.

1832 An Account of Certain New Facts and Observations on the Production of Steam. A paper ready by proxy before the Royal Society on May 3, 1832, and printed in the Transactions of this Society. Copies in the University of Pennsylvania Library, Philadelphia and elsewhere.

* Written by Perkins on the preface of this copy is the explanation of the missing plates. Presumably this proof copy was the one sent to Dr. Jones and never returned by him and thus ultimately it found its way into the library of the Franklin Institute. "Mr. Perkins presents his compliments and will be obliged by your taking the trouble to examine this account of his steam engine and making any comment in the margin of it, that may strike you; after which he will thank you to return it. When the plates are finished, and the corrections made Mr. P. will have the pleasure of sending you a complete copy."

1832 Steam Navigation Improvements. Printed for a Committee of Mr. Perkins' friends. Published and sold by J. Ridgeway, 169 Piccadilly, London, Sherwood and Co., Paternoster Row, London, and E. Wilson, Royal Exchange, London, 1832. Consists of twenty-one pages, a comparative table and a plate. Copies in the American Philosophical Society, Philadelphia, and the Essex Institute Library, Salem, Mass.

1832 to 1837

On the Elasticity of Steam. Found under "Original Communications", not dated, 3 papers read before the Institution of Civil Engineers.

On Causes of Difference of Duty by Cornish and Soho Engines, and on the Improvement of Steam Boilers. A paper read before the above body also not dated, recorded in the *Journal of the Civil Engineers*, for 1837.

Various Articles on the Steam Engine and Boiler, written for the *Magazine of Popular Science and Journal of Useful Arts* during 1836 and 1837. Published at the Lowther Arcade, London, by the Society for Illustration and Encouragement of Practical Science. No copies of these publications can be located by the authors.

1837 On Locomotive Engines and the Means of Supplying Them with Steam. A paper read before the Institution of Civil Engineers, February 7, 1837. Recorded in the *Journal of the Civil Engineers*, copy of which is in the Franklin Institute Library, Philadelphia.

PEDIGREE of the FAMILY of JACOB PERKINS from 1590

JOHN PERKINS—Yeoman, of Newent, Gloucestershire, England. Born in 1590. Died in Ipswich, Massachusetts, in 1654. His children were Jacob and five others.

JACOB PERKINS—Born in 1624 in England. Died in 1700 in Massachusetts. His children were Matthew and five others.

MATTHEW PERKINS—Born in 1665 in Massachusetts. Died in 1738. Married Esther Burnham in 1685. Their children were Matthew and others.

MATTHEW PERKINS—Born April 4, 1687, in Massachusetts. Died May 28, 1737. Married (1) Martha Rogers, on May 14, 1709. She died in 1720. He then married Mary Smith on January 14, 1721. Their children were Matthew and others.

MATTHEW PERKINS—Born May 25, 1725, in Massachusetts. Died May, 1815. He married (1) Ann Greenleaf on Dec. 22, 1748. She died in 1762. Their children were: 1—Benjamin, the Revolutionary patriot, b. Dec. 8, 1749, d. 1797. 2—John, b. Jan. 30, 1751, d. ——. 3—Nathan, b. April 9, 1752, d. ——. 4—Ebenezer, b. Nov. 30, 1753, d. ——. 5—Mary, b. April 22, 1753, m. Nicholas Johnson, d. ——. 6—Abigail, b. Sept. 21, 1756, d. ——. 7—Jane, b. Apr. 14, 1758, m. Lieut. Aaron Pardee on Nov. 17, 1786, d. ——. 8—Esther, b. May 27, 1759, d. ——. 9—Susannah, b. Sept. 9, 1760, d. ——. 10—Ruth and Sarah (twins), b. July 28, 1761, d. ——. 12—Elizabeth, b. June 2, 1762, d. ——.

Matthew Perkins (1725-1815) married (2) Jane Dole, nee Noyes, widow of John Dole of Newburyport, on Jan. 23, 1763. Their children were: 1—Jacob, b. March 2, 1764, d. same day. 2—Edmund, b. July 3, 1765, d. Aug. 17, 1765. 3—Jacob (the inventor), b. July 9, 1766, m. Hannah Greenleaf, Nov. 11, 1790, d. July 30, 1849, in London. 4—Abraham, b. May 4, 1768, m. Elizabeth Knapp, Dec. 14, 1794, d. April 2, 1839. 5—Ann Greenleaf, b. Feb. 2, 1770, d. Aug. 7, 1770. 6—Anna, b. Apr. 15, 1771, d. Aug. 6, 1771. 7—Sarah, b. June 15, 1773, m. Angier March, d. ——. 8—Jane, b. Oct. 5, 1781, d. ——.

JACOB PERKINS—Born July 9, 1766, in Newburyport, died July 30, 1849, in London, England and buried in Kensal Green Cemetery. Married Hannah Greenleaf, Nov. 11, 1790, in Newburyport (she was born in Newburyport on Dec. 26, 1770, and died there on Oct. 5, 1837). Their children were: 1—Hannah Greenleaf, b. Feb. 7, 1792, d. 1813. 2—Sarah Ann, b. Dec. 16, 1793, d. Nov. 25, 1859, in London. 3—Jane, b. Jan. 5, 1796, d. July 14, 1801, in Newburyport. 4—Ebenezer Greenleaf, b. Dec. 29, 1797, in Newburyport, d. Jan. 20, 1842. 5—Angier March, b. Aug. 21, 1799, in Newburyport, d. Apr. 22, 1881, in London. 6—Louisa Jane, b. Sept. 11, 1801, in Newburyport, d. Sept. 29, 1833. 7—Elizabeth, b. May 7, 1804, in Newburyport, d. Apr. 27, 1888. 8—Henrietta, b. July 1, 1806, in Newburyport, d. July 2, 1872, in England. 9—Mary, b. June 29, 1809, in Newburyport, d. there Oct. 24, 1810. With regard to Jacob Perkins' nine children, some additional details may be given.

HANNAH GREENLEAF—Born Feb. 7, 1792, in Newburyport, was the eldest daughter of Jacob Perkins. She died of the plague in Newburyport at the age of 21 years in 1813. At the time of her untimely death she was engaged to be married.

SARAH ANN—Born December 16, 1793, in Newburyport. She was the second daughter of Jacob Perkins and married Joshua Butters Bacon of Boston (b. Apr. 25, 1790, d. Oct. 7, 1863) about 1814. She accompanied her husband to England in 1821 and died there on Nov. 25, 1859. She was buried in the family vault in Kensal Green Cemetery. The children of this marriage were: 1—Alfred, b. 1815 (?) d. ——. 2—Emily, dates unknown. 3—Maria Louisa, b. Apr. 6, 1818, d. Nov. 2, 1892. 4—Josiah Lafayette, b. 1824, d. ——. 5—Sarah Ann, b. Apr. 17, 1825, d. Jan. 29, 1871. 6—Elizabeth Roy, b. 1828, d. Jan. 3, 1912. 7—Joshua Butters, dates unknown.

JANE—Born January 5, 1796, in Newburyport, the third daughter of Jacob Perkins. Died in early childhood on July 14, 1801.

EBENEZER GREENLEAF—Born December 29, 1797, eldest son and fourth child of Jacob Perkins. He appears never to have married. He accompanied his father to England in 1819 where he remained for several years. He died in Newburyport on January 20, 1842.

ANGIER MARCH—Born August 21, 1799, in old Newbury. He was the second son and fifth child of Jacob Perkins. He went to England to join his father in 1821. He was by profession an engineer. He married Julia Georgianna Brown in 1831. Their children were: 1—Angier Greenleaf, born Nov. 14, 1832, died January 20, 1871. 2—Loftus, born May 8, 1834, died April 27, 1891. Angier March Perkins died in London, April 22, 1881, and is interred in the family vault in Kensal Green.

LOUISA JANE—Born September 11, 1801, in Newburyport. She was the fourth daughter and sixth child of Jacob Perkins. She never married and died at Tunbridge Wells, England, at the comparatively early age of 32, on September 29, 1833. Buried in the family vault in Kensal Green.

ELIZABETH—Born May 7, 1804. She was the fifth daughter of Jacob Perkins. She married Dr. Henry Roy of Virginia, probably in 1827. They had two sons who took up their residence in the United States. After the death of her husband she returned to England and died April 27, 1888, and is buried in the family vault in Kensal Green.

HENRIETTA—Born July 1, 1806, in Newburyport. She was the sixth daughter and eighth child of Jacob Perkins. Married Harry W. Chubb who was secretary to the London and Northern Rail Road (which flourished about 1825). He was a member of the Chubb family, of lock fame, and later entered the firm of Chubb and Son, lock and safe makers of 128 Queen Victoria Street, London. Henrietta Chubb died on July 2, 1872.

MARY JANE—Born June 29, 1809, in Newburyport. She was the seventh daughter and ninth child of Jacob Perkins. She died in infancy on October 24, 1810, and was buried in Newburyport. Continuing the family descent, it will be remembered that Angier March Perkins had two sons: 1—Angier Greenleaf, born Nov. 14, 1832, the eldest son. He was by profession an engineer. He married Ellen Carr. He died at the early age of 38 at No. 18 Hornsey Street, Islington, London, on January 20, 1871, and was buried in the family vault in Kensal Green. 2—Loftus, born May 8, 1834, the second son. He was also an engineer by profession. Married in 1866 Emily, daughter of the Reverend William Patton, D.D. (1798-1879), of Philadelphia. Loftus Perkins died April 27, 1891, and is buried in the family vault in Kensal Green. There were two sons of this marriage: (1) Ludlow Patton Perkins, who died some years ago and (2) Loftus Patton Perkins, born May 9, 1867, who lived during the writing of most of this book and who died suddenly in London, Sept. 5, 1940.

INDEX

Index

Index

Index

Index

Index

Index

Index